SEPTEMBER 1960

Journal

VOL. 52 • NO. 9

AMERICAN WATER WORKS ASSOCIATION

Focusing on the future—
Willing Water
takes a close look
at water supply research

Two parts—Part 1 (AWWA Directory is Part 2):

WATER SUPPLY RESEARCH
Allen, Berry, Faber, Larson

UTILITY MANAGER RESPONSIBILITIES
Seeger

USE OF AERIAL PHOTOGRAPHY
Staub, Bollinger

REVISION OF METER STANDARD
Committee Report

USE OF HIGH-TENSILE STEELS
Price, Jackson

CORROSION TESTS WITH HOT WATERS
Guest

SUBMERSIBLE WELL PUMPS
Erickson

WATER QUALITY STANDARDS
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SUGGESTED METHOD FOR SELENIUM DETERMINATION
Magin, Thatcher, Rettig, Levine

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GROUND WATER CONTAMINATION
Task Group Report

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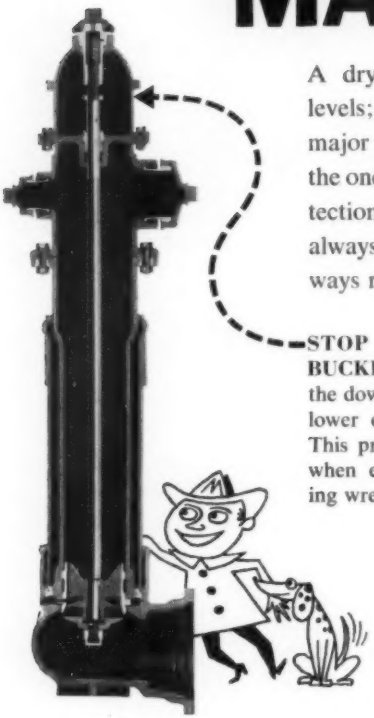

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Journal

AMERICAN WATER WORKS ASSOCIATION

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September 1960

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PART 1

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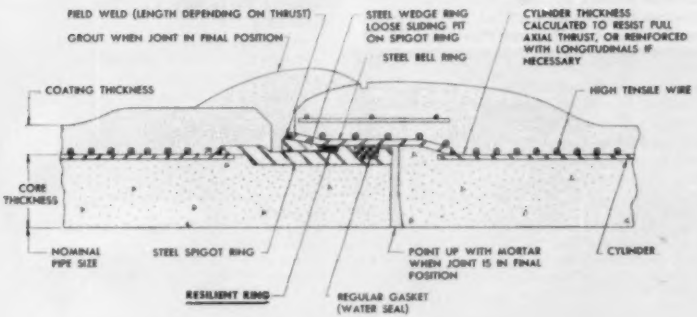
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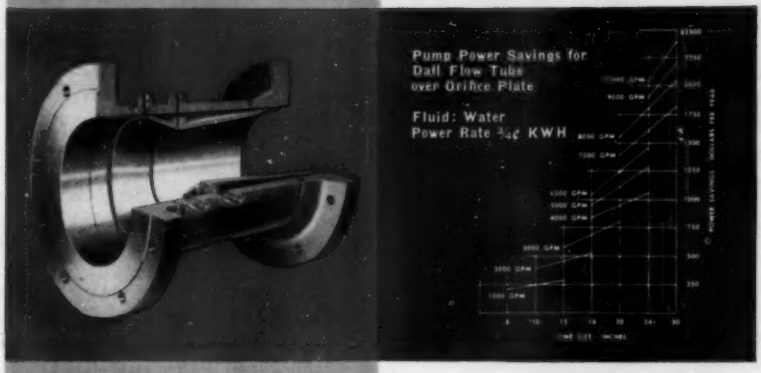

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AWWA SECTIONS

Sep. 14–16—Virginia Section, at Cavalier Hotel, Virginia Beach. Secretary, Edward H. Ruehl, R. Stuart Royer & Assoc., 15 W. Cary St., Richmond.

Sep. 14–16—New York Section, at Saranac Inn., Upper Saranac Lake. Secretary, Kimball Blanchard, New York Branch Sales Office, Neptune Meter Co., 22-22 Jackson Ave., Long Island City 1.

Sep. 21–23—Michigan Section, at Park Place Hotel, Traverse City. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing.

Sep. 21–23—North Central Section, at Lowry Hotel, St. Paul, Minn. Secretary, Carl A. Flack, Registrar, Water Dept., 216 City Hall, St. Paul, Minn.

Sep. 25–27—Missouri Section, at Governor Hotel, Jefferson City. Secretary, Warren A. Kramer, Chief, Water Supply, Div. of Health, State Office Bldg., Jefferson City.

Sep. 28–30—Wisconsin Section, at Loraine Hotel, Madison. Secretary, Harry Breimeister, Bureau of Engineers, 607 Municipal Bldg., Milwaukee.

Sep. 28–30—Canadian Section, Maritime Branch, at Charlottetown Hotel, Charlottetown, P.E.I. Secretary, J. D. Kline, Gen. Mgr., Public Service Com., Halifax, N.S.

Oct. 6—Connecticut Section, at Sanford Barn, Hamden. Secretary, Donald W. Loiselle, Supt. of Supply, Bridgeport Hydraulic Co., Bridgeport.

Oct. 6–7—Intermountain Section, at Newhouse Hotel, Salt Lake City, Utah. Secretary, M. W. Snell, Supt., Power & Light Dept., Soda Springs, Idaho.

Oct. 9–12—Alabama-Mississippi Section, at Tutwiler Hotel, Birmingham, Ala. Secretary, Ernest Bryan, McWane Cast Iron Pipe Co., Box 2601, Birmingham, Ala.

Oct. 16–19—Southwest Section, at Galvez Hotel, Galveston, Tex. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 19–21—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 20–22—New Jersey Section, at Madison Hotel, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

(Continued on page 8)

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Coming Meetings

(Continued from page 6)

Oct. 24–27—Rocky Mountain Section, at Broadmoor Hotel, Colorado Springs, Colo. Secretary, Harrison F. Kepner, Vice-Pres., Dana Kepner Co., 550 Alcott, Denver, Colo.

Oct. 25–27—California Section, at Lafayette Hotel, Long Beach. Secretary, F. F. Watters, Hydr. Engr., State Bldg., Civic Center, San Francisco 2.

Oct. 26–28—Ohio Section, at Deshler-Hilton Hotel, Columbus. Secretary, J. Howard Bass, Henry P. Thompson Co., 1720 Section Rd., Cincinnati.

Change in Date

Nov. 2–4 (instead of Oct. 19–21 as formerly scheduled)—Chesapeake Section, at Sheraton Park Hotel, Washington, D.C. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Nov. 9–11—North Carolina Section. at Robert E. Lee Hotel, Winston-Salem. Secretary, T. Z. Osborne, Asst. Director of Public Works, Greensboro.

Nov. 13–16—Florida Section, at Galt Ocean Mile Hotel, Fort Lauderdale. Secretary, John G. Simmons, Plant Supt., Water Dept., West Palm Beach.

OTHER ORGANIZATIONS

Sep. 18–22—NEWWA, Queen Elizabeth Hotel, Montreal, Que.

Sep. 26–30—Conference and exhibit and annual meeting, Instrument Society of America, Coliseum, New York, N.Y.

Oct. 2–6—WPCF, Convention Hall, Philadelphia, Pa.

Oct. 10–14—Fall general meeting, AIEE, Chicago, Ill.

Oct. 17–18—Annual meeting, Interstate Commission on the Delaware River Basin, Pocono Manor Inn, Pocono, Pa. Write: James H. Allen, Exec. Secy., Incodel, 341 Suburban Station Bldg., Philadelphia 3, Pa.

Oct. 17–21—48th annual National Safety Congress, Chicago, Ill., with sessions on industrial safety scheduled for Conrad Hilton, Pick-Congress, Sheraton Towers, Morrison, and La Salle hotels. Write: R. L. Forney, Secy., National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

Oct. 24–28—9th annual water works management short course, cosponsored by the Illinois and Indiana sections, AWWA, at Allerton Park, Monticello, Ill. Write: T. E Larson, Head, Chemistry Sec., State Water Survey Div., Box 232, Urbana, Ill.

Oct. 31–Nov. 4—APHA annual meeting, San Francisco, Calif.

Nov. 7–11—Course on "Radioactive Pollutants in Water," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

Nov. 14–18—Course on "Radionuclides in Water," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

Nov. 27–Dec. 2—Annual meeting, ASME, Statler Hilton Hotel, New York, N.Y.

A Nalco PRODUCT MANAGER

Answers Questions on Coagulation

New Chemicals and New Techniques Help Solve Problems

J. T. Burke, Manager
Nalco Coagulation Chemicals Department

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Answer: Continuous production of water of the necessary clarity and quality to meet end-use requirements; with the flexibility to handle changing conditions in input water characteristics. A good coagulation program should also increase the length of filter runs.

Question: What are some of the more recent improvements in the field of coagulation?

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Question: What is the best approach to solving a specific coagulation problem?

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Answer: Nalco's basic background is successful water treatments. The Coagulation Chemicals Department at Nalco is made up of "specialists' specialists": men whose sole job is to provide Nalco Representatives and their customers with the materials and assistance necessary to solve coagulation problems.

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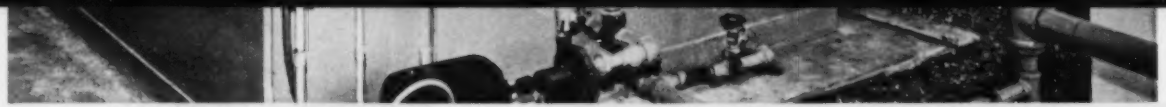

This Permutit packaged automatic plant treats water for Bahia Vista Estates, de luxe trailer community, in Sarasota, Florida. System contains degasifier, Precipitator, chemical feeders, two Automatic Valveless Filters.

New way to save money when you treat water for smaller communities

You're looking at a new idea in water treatment: a *packaged, automatic* plant, custom engineered by Permutit to save you construction, installation and operating dollars.

Such systems are now available for smaller communities using from 10 to 100 gpm. . . and at economical cost.

This is possible because of the range of sizes in which we offer standard, package equipment for each step in water treatment, including: removal of carbon dioxide, oxidation of ferrous iron or hydrogen sulfide, softening, removal of turbidity, chlorination, and filtration.

Fully automatic, low-cost operation. Your Permutit plant operates automatically, practically runs itself day in and day out, keeping your labor and operating costs at a minimum. Even the filters automatically backwash themselves at the right time, rinse themselves, and go back into operation—without so much as a glance from an operator! The unique Permutit® Automatic Valveless Gravity Filter makes this possible.

Send for prices, details. At no obligation to you, we'll gladly give full details on how a Permutit packaged plant can be tailored to your local conditions. Write to: Permutit Division, Pfaudler Permutit Inc., Dept. JA-90, 50 West 44th Street, New York 36, N. Y.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS...the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

Costs go down

as fast as the pipe!

Lancaster, Pennsylvania: Ten miles of 42-inch ID steel main are an important addition to the local water supply system. The 100 per cent Dresser-Coupled line was laid by Frank Kukurin & Sons and Alconn Utilities.

AND DRESSER-COUPLED steel pipe goes in fast! Steel pipe in lengths up to 50-feet needs fewer connections, and Dresser® Couplings make those connections fast... two man-minutes per bolt. Steel pipe is lighter... saves freight costs and provides easier handling at the job-site. When you use Dresser-Couplings to join steel pipe, you eliminate the need for expensive, specialized joining equipment. The only tool you need is a simple hand wrench. For *least initial cost* and *lowest maintenance* on your next water line, specify Dresser-Coupled steel pipe.

Two man-minutes per bolt for permanent, leak-proof joints!

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Chicago
Houston
New York
Philadelphia
S. San Francisco
Toronto & Calgary

DRESSER
MANUFACTURING DIVISION

ONE OF THE DRESSER INDUSTRIES

Pipe being primed at coating yard specially set up by Koppers Contract Coating Department for a large water supply project.

3/32" MAKES ALL THE DIFFERENCE

Steel water pipe will last much longer underground with the armor-like protection which a 3/32" coating of Bitumastic 70-B AWWA Enamel gives it. This corrosion-preventive coating is vital to the long-life of water lines.

Bitumastic Enamel has helped steel water lines set high flow capacity records of 40 years and more. Proven performance is one reason why so many water supply engineers are specifying steel pipe, lined and coated with Bitumastic 70-B AWWA Enamel, for their projects today. A lining of this enamel gives a uniformly smooth inside surface that has proved to have the highest flow coefficient available.

You can obtain more information about the economies of Bitumastic 70-B enameled steel pipe from Koppers Company, Inc., Tar Products Division, Dept. 1161 Pittsburgh 19, Pennsylvania.

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ENAMELS

THE MARK OF THE 100-YEAR PIPE

PERMANENTLY YOURS: CAST IRON PIPE

Installed—
it stays installed

One thing sure about cast iron pipe—once it's in the ground, it's there for keeps! Over 100 American utilities, having used cast iron pipe steadily for more than a century, can testify to that. And *modern* cast iron pipe gives you greater assurance than ever: great beam strength resists heavy surface traffic; tremendous load resistance absorbs even the most forceful pressures. In fact, when you select cast iron pipe, you can anticipate no major repairs in your water supply system for the next hundred years!

Cement-lined—it stays cement-lined

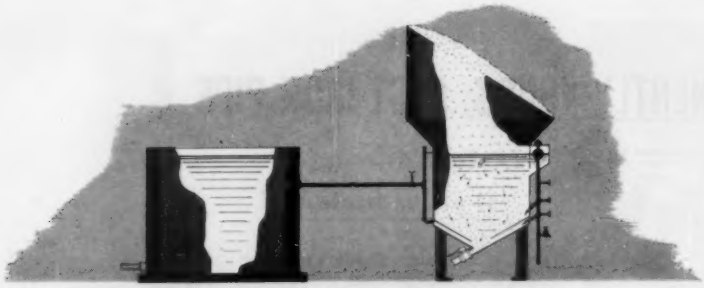
A smooth coat of cement lining along the inner wall helps prevent the formation of flow-reducing particles. No matter how strong the water is, cast iron pipe always assures a free, steady flow.

Joined—it stays joined

Bottle-tight, rubber-ring joints give you leak-proof protection at the most vulnerable points of your system. Vibrations, surface traffic and washouts present no problems to cast iron pipe. Inherent ruggedness . . . built to perform under all adverse underground conditions . . . repair-free service for at least a century—all good reasons why your choice should be that of water utility experts everywhere. America's greatest water carrier: cast iron pipe.

Cast Iron Pipe Research Association,
Thos. F. Wolfe, Managing Director,
3440 Prudential Plaza, Chicago 1, Ill.

CAST IRON PIPE

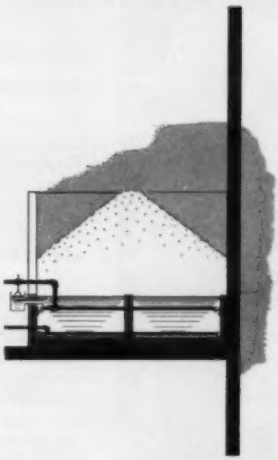


SALT STORAGE

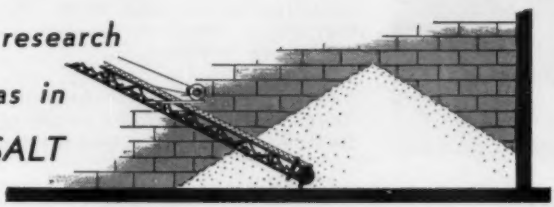
How it can affect design of water softening installations

The method used to store salt must be considered when planning a water softening plant. Dry salt storage, for example, requires different facilities from brine storage. And "wet storage" (dry salt stored under covering brine) has its own special design needs. Whatever method is chosen, however, its effect on plant design is greater than ever, since **more** salt and brine are needed in today's higher-capacity softening plants.

If you would like help in planning modern, large-scale salt-storage facilities, contact International Salt Company. With over 50 years of experience and continuing research in all phases of salt handling and brine production, International can suggest many new and practical ideas in connection with salt purchase, storage and dissolving for regenerating ion exchangers. This service is impartial and comprehensive. It costs you nothing.



Service and research are the extras in STERLING SALT



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formerly SMITHCO

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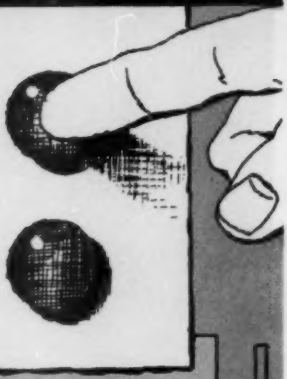

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You press the starter button with assurance because you know the FloWay pump has been designed and constructed to handle the pumping job without a murmur. Proven performance, whether in process pumping, booster, transfer, pipe line, cooling, or in practically every other type of installation, has shown that FloWay is equal to the exacting needs of industry. Send for Bulletin #14 which describes the full line of FloWay industrial pumps.

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It's standard on all Badger meters. This dovetail thrust roller insert fits vertically into the thrust roller slot to form a smooth track on which the roller rides countless times — quietly and without wear. With this slot now 77% shorter, original chamber strength is retained and distortion eliminated.

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The thrust roller insert is just one of many refinements to emerge from Badger's concentration on meter research and development. See your Badger representative for details. Ask him, too, about the Read-o-Matic. Proof that answers for better water metering come first from Badger.

Badger Water Meters

BADGER METER MFG. CO. • 4545 W. Brown Deer Rd.
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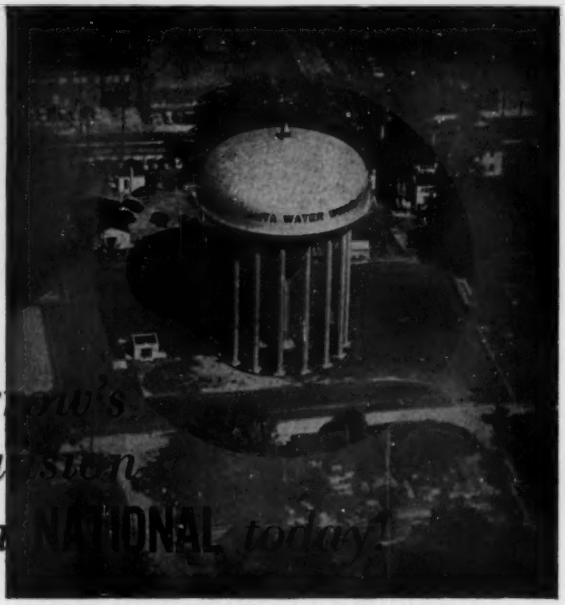

For tomorrow's expansion call in NATIONAL today!

Like Atlanta, Ga., *you* too can meet tomorrow's increased water demands with *clean water mains*. When the coefficient of sections of Atlanta's 45 year old main dropped to a low of 44, Waterworks General Manager, Paul Weir ordered National cleaning. Results were outstanding. Water pressure and capacity doubled, giving better fire protection and higher water pressure to outlying sections.

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a boy can open or close the new ORISEAL® VALVE!

An easy turning Curb Valve with all the features you've looked for.

Try it . . . Prove to yourself how easy this valve will open and close. The Teflon coated straight plug turns easy even after prolonged idleness.

The Key to the dependable long-life performance of the Oriseal is in its simple, practical design. The entire valve assembly is only six parts . . . the three "O" rings in the sturdy valve body, the Teflon coated straight plug . . . the valve cap.

We are happy to offer the Oriseal as another beneficial product developed for the Water Industry . . . the direct result of over a century of experience and tradition for quality "craftsmanship". See your Mueller representative or write Dept. B, Mueller Co., for your copy of "The Oriseal Valve —Test Results".

The Oriseal turns easy without grease . . . has no mechanical seating device to wear or cause sticking . . . the seat is protected against damage and erosion.

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Factories at: Decatur, Chattanooga, Los Angeles; In Canada: Mueller, Limited, Sarnia, Ontario.

WILLIAM KERIVAN, Chief Filter Plant Operator, Billerica (Mass.) Water Treatment Plant, says:

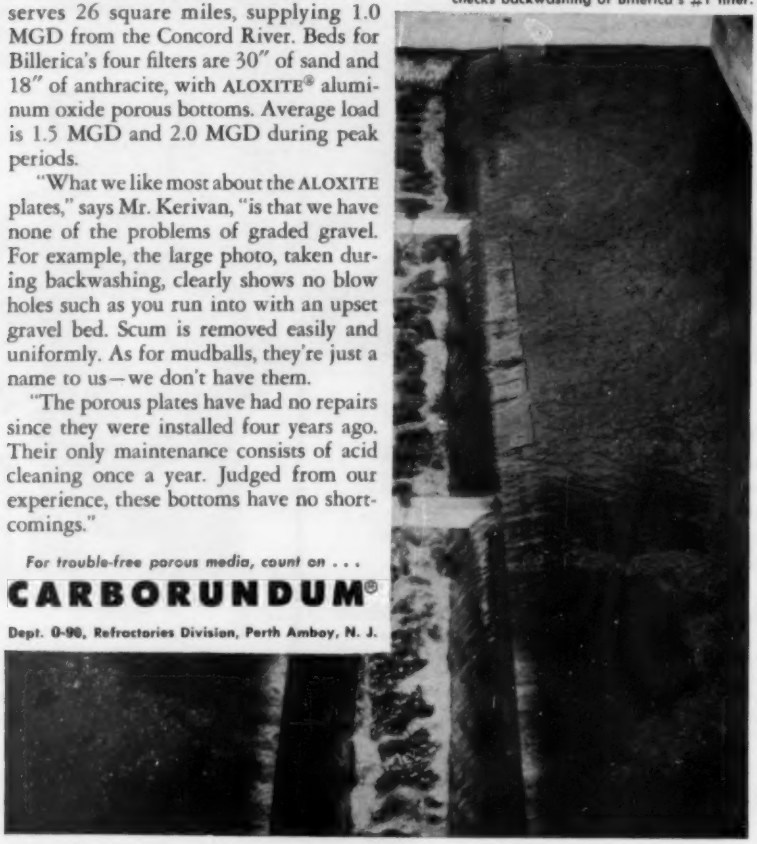
"Our porous underdrains give completely trouble-free service..."

The Billerica Water Treatment Plant serves 26 square miles, supplying 1.0 MGD from the Concord River. Beds for Billerica's four filters are 30" of sand and 18" of anthracite, with ALOXITE® aluminum oxide porous bottoms. Average load is 1.5 MGD and 2.0 MGD during peak periods.

"What we like most about the ALOXITE plates," says Mr. Kerivan, "is that we have none of the problems of graded gravel. For example, the large photo, taken during backwashing, clearly shows no blow holes such as you run into with an upset gravel bed. Scum is removed easily and uniformly. As for mudballs, they're just a name to us—we don't have them.

"The porous plates have had no repairs since they were installed four years ago. Their only maintenance consists of acid cleaning once a year. Judged from our experience, these bottoms have no shortcomings."

Mrs. Barbara E. Hawkes, Chief Chemist, checks backwashing of Billerica's #1 filter.



For trouble-free porous media, count on . . .

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EASE OF INSTALLATION

American Concrete Cylinder Pipe is easy to install, a fact that many contractors have proved repeatedly. Standard laying lengths of 32 feet together with carefully scheduled and executed trenchside delivery reduce handling time to a minimum. ■ The joints of American Concrete Cylinder Pipe are fabricated of accurately sized steel bell and spigot rings which mate perfectly and easily every time. A rubber gasket provides a permanent watertight seal which eliminates the need for tedious caulking and skilled workmen. ■ Properly installed, American Concrete Cylinder Pipe can be backfilled immediately after jointing is completed thereby reducing open trenches to a minimum. ■ The ease and confidence with which you can install American Concrete Cylinder Pipe is only one of the reasons it should be considered for your next pipeline project. Let an American Sales Engineer tell you about the many other long-term economies available to you.

American Pipe and Construction Co. • Los Angeles • San Diego • Hayward • Portland
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A MEMBER OF THE AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

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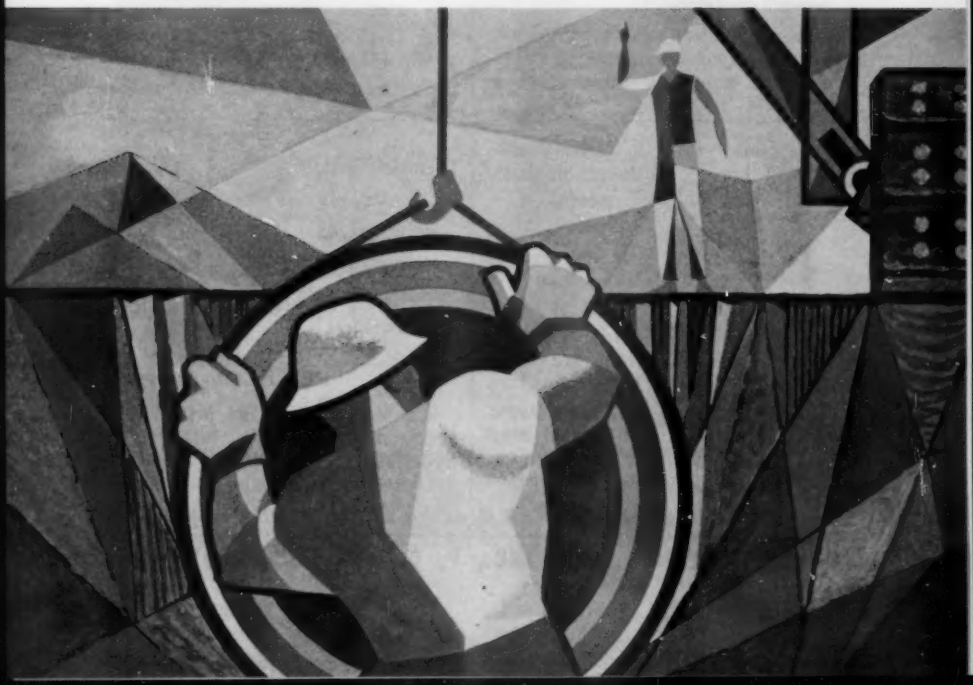

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Automatic Valves

ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

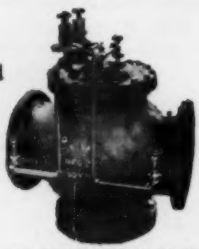
SURGE-RELIEF VALVE

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.

FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished

REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

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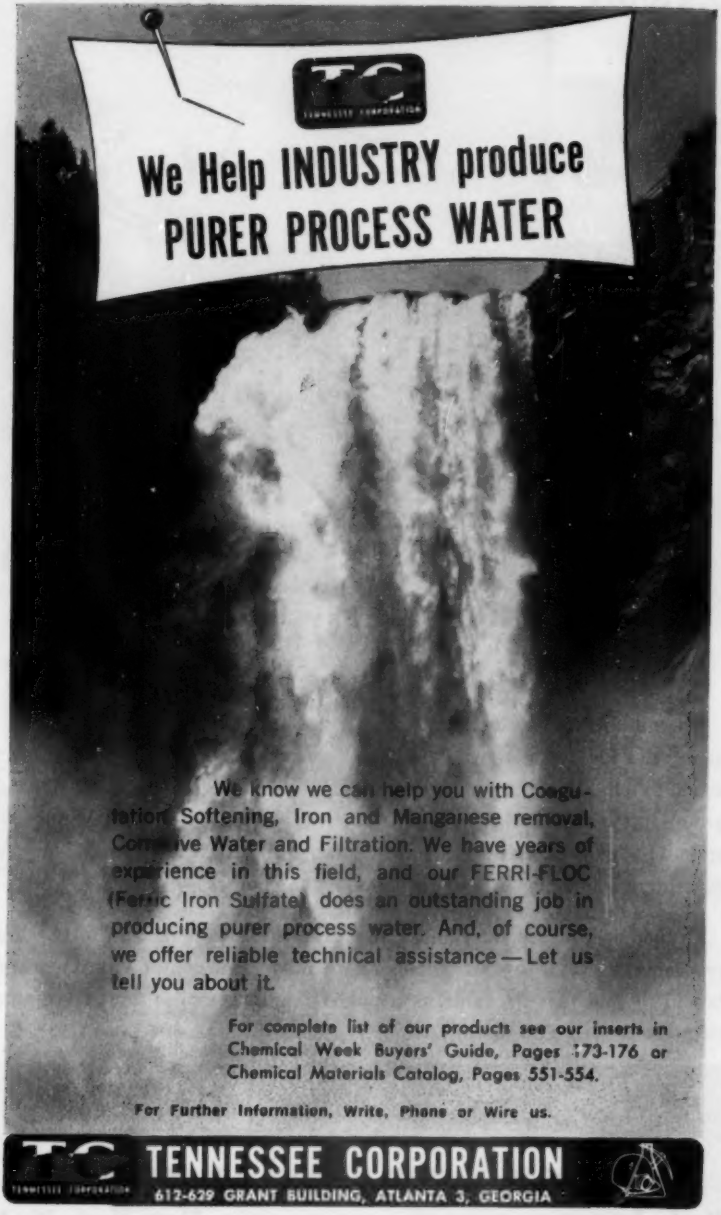
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Slide Film

with

Sound and

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$35 a copy

THE STORY OF WATER SUPPLY

Based on AWWA's million-copy bestselling picture booklet of the same name, the film version uses lively color cartoon slides and synchronized sound to tell "The Story of Water Supply" to schools, civic clubs, and other groups of your neighbors and customers. Attractive to both youngsters and adults, and easily understood by all, the effectiveness of this 15-minute presentation is being proved throughout the country.

Whether you use the film as an introduction to a talk on local water problems or lend it to your schools (a teaching guide comes with it), you're bound to find that its value as a public relations tool is worth far more than the modest $35 cost.

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AMERICAN WATER WORKS ASSOCIATION

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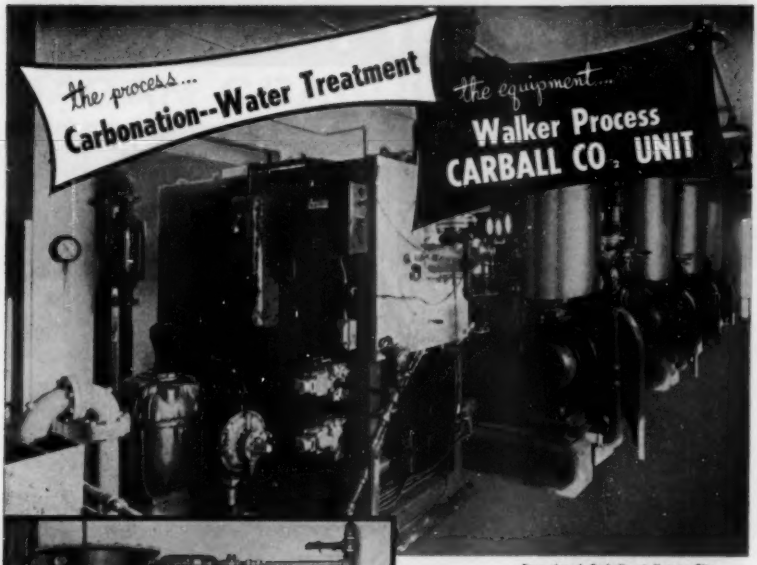

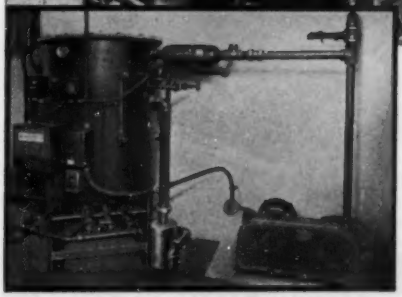

Four size 4 Carballs at Kansas City, Mo. burn either gas or oil to produce max. of 40,000 lbs. CO_2/day. Size "O" unit at left produces 870 lbs. CO_2/day for Jefferson, Iowa Water Plant.

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CO_2 UNIT

Walker Process now offers carbonation units for all lime softening plants from the very small to the largest. Sizes range from the new "OO" unit with minimum capacity of 55 lbs. CO_2/day to the No. 4 at maximum output of 10,000 lbs. CO_2/day.

Engineers can readily provide an entire carbonation system by simply specifying the appropriate size CARBALL in combination with Walker Process SPARJER diffusers . . . . . assuring

50% More CO_2
Clean, Tasteless Gas
100% Combustion
Unique Absorption Method
Economical Operation
Factory Tested Package System

Write for bulletins 7W83 - 7W85 and 7W88

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pH Meter Mod. 115

A full-fledged line-operated pH Meter of remarkable accuracy and stability at the low price of

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- SIMPLE IN OPERATION AND MAINTENANCE
- FAST AND DEPENDABLE IN SERVICE

Write for Bulletin #225, also for literature on other Line-Operated and Battery-Operated Photovolt pH Meters

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Florida City Water Plant

SAVES TIME AND MONEY WITH HAGAN COAGULANT AID

Robert Ankney inspects filter

Coagulant Aid Feeder

Vero Beach, Florida, Water Treatment Plant

Quick case history—reading time 57 seconds

The City of Vero Beach, Florida, has a 6 mgd softening plant that draws water from six shallow wells. The plant formerly used activated silica as an aid to coagulation. While results were satisfactory, the plant investigated other coagulant aids in the hope of increasing the efficiency of their operation. After exhaustive laboratory tests and plant trials, Hagan Coagulant Aid #7 was adopted as it is easy to apply, requires less storage space and only a minimum of supervision. A feed rate of only ½ ppm was set up for the Hagan Aid.

A recent test showed that filters can be operated at 10% above rated capacity for 230 hours with only a 4-foot loss of head; normal filter runs are of 200 hours duration.

Another saving showed up during a recent expansion, when Gee & Jensen, Consulting Engineers, incorporated feeding equipment specifically designed for Hagan Coagulant Aid #7 into their plans for the new plant. This equipment cost approximately one-fourth as much as equipment that would be needed for activating silica.

Hagan Coagulant Aids are non-toxic, easy to handle, and produce a large, tough floc that speeds settling time and reduces carryover. They may be dry-fed or slurry-fed as desired. Write for Bulletin HSP 919 for information on the complete line of Hagan Coagulant Aids.

HAGAN

CHEMICALS & CONTROLS, INC.

HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO.; HALL LABORATORIES; BRUNER CORP.

Specified: 100 years of life!

SPECTACULAR UNDERWATER PIPELINE DISCHARGES 600 MILLION GALLONS PER DAY THROUGH CONCRETE PRESSURE PIPE

Specifications of the Los Angeles Hyperion Sewerage expansion project required a permanent underwater pipe line to carry 600 million gallons per day of effluent five miles out into Santa Monica Bay for disposal through a diffuser system. Hyperion engineers chose CONCRETE PRESSURE PIPE for permanence. No alternate was allowed for the 100-year minimum design life. Sustained high carrying capacity and freedom from maintenance are other factors in the overall economy of CONCRETE PRESSURE PIPE that make it ideal for an installation of such special character.

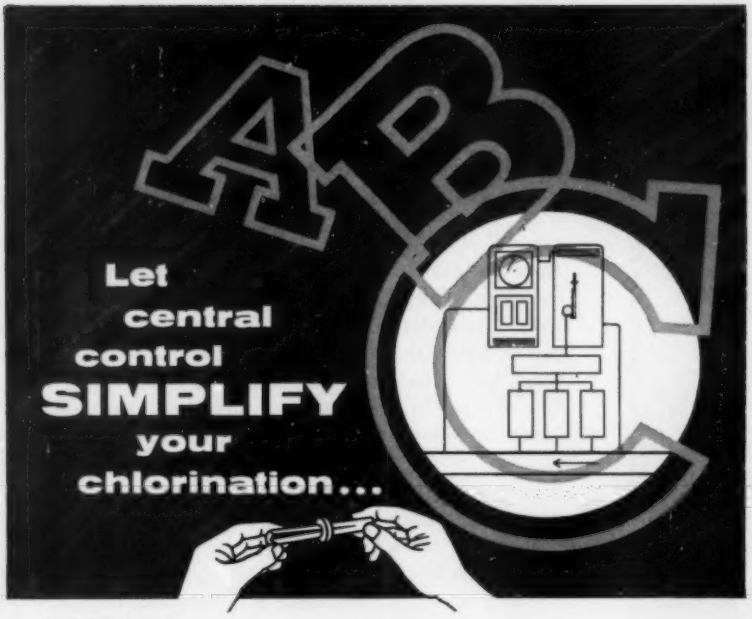
The great strength of CONCRETE PRESSURE PIPE was demonstrated in the handling and joining of 90-ton, 24-foot lengths of 144-inch diameter pipe. These were assembled eight at a time and secured to a pontoon for towing to the laying site. The concrete pipe joints sealed with rubber gaskets conformed to rigid testing and inspection requirements and permitted joining the pipe underwater in ocean depths up to 200 feet.

Large project or small—underwater or underground—CONCRETE PRESSURE PIPE is your best investment for now and the future.

WATER FOR GENERATIONS TO COME

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street, Chicago 1, Illinois



W&T **COMPOUND-LOOP CONTROL**

By residual analysis and information feedback, Wallace & Tiernan Compound-loop Control adjusts chlorinator feed rates to changing water flows and chlorine demands. You can add W&T Remote Residual Recording and Controlling Components throughout your water system and centralize control at any desired location. You select the desired residual on a central panel and the Compound-loop System maintains that residual faithfully.

Remote recording by W&T gives you duplicate residual records and minute-to-minute information where it helps guide operation. Remote controlling by W&T lets you adjust a chlorinator miles away. And W&T Remote Components adapt to almost any system, any type of control.

With remote residual recording and controlling by Wallace & Tiernan you centralize control... save time and operating expense... extend the advantages of the Compound-loop method.

For more information, write Dept. S-142.05

WALLACE & TIERNAN INCORPORATED

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 52 • SEPTEMBER 1960 • NO. 9

Progress in Water Supply Research

A Symposium

A symposium presented on May 16, 1960, at the Annual Conference, Bal Harbour, Fla.

Organization and Activities of the British Water Research Association—*Ronald G. Allen*

A paper presented by Ronald G. Allen, Director, Water Research Assn., Redhill, Surrey, England.

AT the beginning of the twentieth century, it was evident that Great Britain's lead in industrial development and commerce was threatened. While British industry was dependent on an older pattern of production and trade, other countries, with an Industrial Revolution beginning later than that in Britain, were competing in world markets with the aid of up-to-date facilities. World War I showed that the pace of the technical development of Britain's competitors presented a serious challenge to her future trade, and, although enlightened industrialists were already beginning systematically to recruit trained scientists, in 1916 the government took the initiative by setting up a department having the responsibility of fostering the application of science in industry. The technical research organization so created was called the Department of Scientific and Industrial Research (DSIR). It was controlled by a committee of the Privy Council and sought to work *for* industry by the creation of "research establishments" covering prescribed technical and scientific disciplines. Additionally, it sought to work *with* industry by offering scientific and financial support for organizations established by a specific industry to study the common and scientific problems of its individual firms. Such organizations came to be known as "research associations," or RA's. The Water Research Association is the newest of the 50 research associations that qualify for government assistance

through DSIR. Before the function and progress of DSIR are discussed, the basic structure and common aims of the research association movement as a whole should be described.

Nature of Research Associations

Each research association is set up by an industrial group to study its common scientific and technical problems.

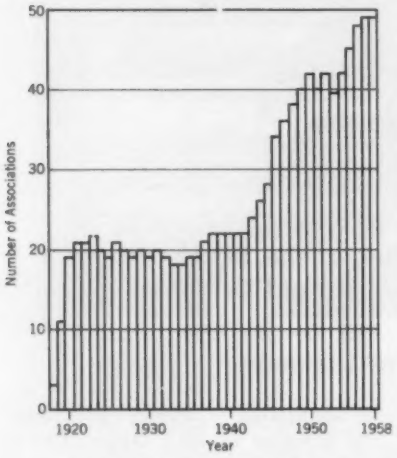

Fig. 1. Numerical Growth of Research Associations

By special arrangement, organizations outside the United Kingdom and the Commonwealth can join many of the research associations. At present, there are 50 research associations in the United Kingdom.

Therefore, an association represents a fusion of the cooperating member firms on the one hand and their permanent staffs and research facilities on the other. The association achieves individual status by incorporation as a nonprofit company with a memorandum and articles of association setting out its objectives and its structure. Its affairs are managed by a council, with supporting committees, elected by the membership and composed mainly of the administrators and technicians of the industry. It may find it desirable to co-opt others, such as eminent engineers or university scientists, who can act as advisors because of their special knowledge.

The principal executive officer is the director of research, who is appointed by the council to be responsible for the operation of the association under the council's general guidance. Normally, a headquarters with laboratories, library, workshops, and facilities for semi-industrial pilot-scale experimentation is established at a place that is convenient for the recruitment of research personnel, affords reasonable access to members, and meets the special requirements of the research.

Normally an association has a number of classes of membership; all firms having a direct interest in the work of the association would be admitted to full membership. By special arrangement, organizations outside the United Kingdom and Commonwealth can join many of the associations if their membership is generally to mutual advantage. Often an associate class of membership is available with more limited rights for individuals and firms having only marginal interests in the main industry.

Figure 1 shows the numerical growth of research associations over the past 40 years; Fig. 2 shows the expansion of their income. At the present time, there are 50 associations whose combined income in 1959 amounted to approximately £7,000,000 ($20,000,000).

Income of Research Associations

Members provide the major part of an association's income, and, normally, they are asked to guarantee their sub-

scriptions for several years, often five. This gives stability to the association's finances. Without financial stability, it would not be possible to plan research, much of which is usually of a long-term nature. Financial stability also enables the director to envisage a broad program of research likely to attract suitable staff personnel and, equally important, additional members.

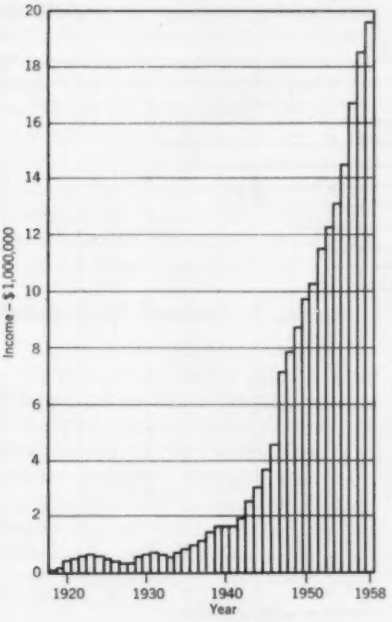

Fig. 2. Combined Income of Research Associations

At the present time, the income of 50 research associations amounts to approximately $20,000,000.

Rates of subscription are determined by the members at annual general meetings. The rates may be calculated in a number of ways. Some associations find it convenient to base their rates on invested capital, total wages paid, or turnover; others prefer an assessment against the number of employees or the consumption of a particular raw material. But whether the rate is based on a financial assessment —this has special advantages at times when the trend of the economy is inflationary—or on some commodity value, subscriptions are always related to the size of the firm. Very frequently payment is made directly to the association, although it is sometimes convenient for trade associations to collect the subscriptions and pass them on as a single sum. Such a trade body is often in a position to guarantee a composite subscription, and, in one or two instances in Britain, a levy is collected on statutory authority from all the firms in a specified industry. Research associations are fortunate in having their subscriptions and membership contribution officially regarded as industrial expenses exempt from income tax. Any income the association may have from investment or royalties is also exempt from taxation.

Government Participation

No research association is able to secure government support, technical or financial, without first being in a position to demonstrate that the industry concerned is alive to the need of cooperative research and is prepared to provide funds for its operation on a worthwhile scale. This status frequently depends on the association's annual income guaranteed by its members. At the present time, £20,000 ($57,000) would most likely be regarded as an indication of satisfactory status.

A grant is administered by DSIR and is made for a period of 5 years, after which it may be renewed. To obtain a grant, the association submits a 5-year program of research, to-

gether with a statement of its existing circumstances and its prospects for the future. A committee of the Advisory Council for Scientific and Industrial Research considers the application and may recommend the terms of a grant, taking into account the character of the industry, with particular reference to its scientific standing and national importance.

must be forthcoming before an association becomes qualified for a grant. A block grant is made as a fixed proportion of this minimum, and an additional grant is offered in proportion to any further income, up to a stated total. The additional portion of the grant is in the nature of an incentive to members to expand and develop the association's activities as rapidly as

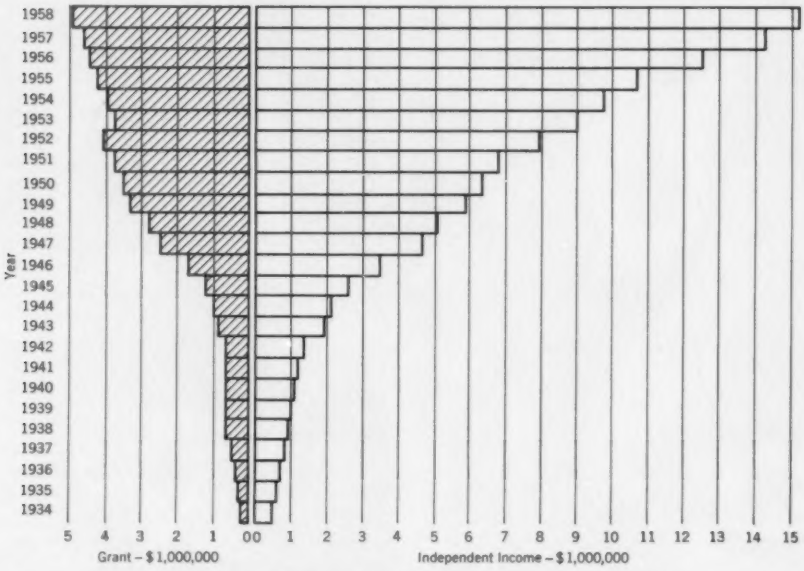

Fig. 3. Grant and Independent Income of Research Associations

Members provide the major part of an association's income. A grant is made by DSIR for a period of 5 years.

Table 1 shows the income of some research associations for 1959, indicating separately membership (independent) income and government grant. Figure 3 shows the growth of grant and membership income from 1934 to 1958. The grant offered is always related to the amount of money advanced by industry, and a minimum income

possible, to a level appropriate to the needs of the industry and community. In accepting a grant, the associations do not surrender their independence. The grant from DSIR is pooled with that of the members, to be spent in accordance with the research program approved by the council on behalf of the membership.

DSIR normally nominates one or two experts as members of the council and appoints one of its own officers to attend council meetings. He has no vote, but provides a link with DSIR headquarters and is able to offer advice based on the experience of other research associations. DSIR also appoints, in consultation with the research association, one or two "visitors" from independent academic and industrial backgrounds to act as impartial observers of the work and functioning of the association. They are available to make an assessment of the contribution that the association has made to the research needs of the industry at the end of the 5-year program, when a continuation of the grant would be under consideration.

Activities of Research Associations

A research association is essentially a scientific organization, but its work differs from academic research in that it is directed purposefully towards the advancement of the technology of a specific industry. Its program is essentially practical in outlook, concentrating on problems chosen by its members as being of the greatest industrial importance. Its work leads to more efficient production and to economies in manpower and materials. The associations do not, however, pursue research solely with the thought of quick returns. An adequate measure of basically fundamental research should be provided for. Commonly, associations divide their resources equally between basic research, applied research, and member services; the latter comprises information, advisory, liaison, and educational services.

Normally, the responsibility for drawing up a program of research, and for watching its progress, is delegated to a research committee having powers to co-opt experts from various fields—academic, technical, and industrial. The program can then be based on the best practical and academic experience and can be designed to avoid duplication of effort and to suit the possibly competing needs of its members. It is likely to include research into raw materials, industrial processes, products, production economics, social and human aspects of the industry, and education, as well as providing for the operation of an information and advisory service backed by technical and scientific library services.

Where facilities and staff are needed for a special investigation, the association may provide funds for extramural research, to be used, for exam-

TABLE 1

Income of Research Associations: Metal, Fuel, Engineering, and Paint—1959

Research Association	Independent Income *$1,000*	Government Grant *$1,000*
Cast Iron	415	143
Coal	701	229
Coke	300	100
Electrical	1,015	286
Hydromechanics	129	57
Internal Combustion Engines	157	86
Iron & Steel	1,988	343
Marine Turbine	1,187	200
Motors	386	157
Nonferrous Metals	472	143
Paint	172	86
Production Engineering	729	257
Scientific Instruments	114	43
Ships	872	143
Springs	29	14
Steel Castings	186	86
Tar	243	86
Water	114	72
Welding	300	143

ple, at technical colleges or universities. If the association has enough space, apparatus, and staff, confidential work paid for by individual member firms can be carried out by agreement with the council. Cooperative work, however, is the main job of an association, and, normally, staff and facilities are fully occupied in this way.

The information obtained by an association with funds provided by its membership is for the benefit of those members, and the results of investigations, which are of immediate application, are communicated to members first. Information is distributed as technical reports and memoranda, supplemented as the need arises by instructional courses and panel discussions. Most associations, however, release information for general publication soon after its receipt by members, a course almost always adopted for much of its basic research.

Water Research Association

Through the efforts of the British Waterworks Association and the Institution of Water Engineers, the Water Research Association (WRA) was incorporated, under the Companies Act of Great Britain, at the end of 1953, with a memorandum and articles of association based on the DSIR model. By 1955, sufficient funds had been secured to permit the appointment of a director of research and to provide temporary laboratory accommodations for his future staff.

From the beginning, WRA sought to conform to the pattern of grant-aided research associations, and, although its program of research was limited by lack of funds, its work had attracted sufficient attention by 1958 for membership of WRA to have increased to 248 and annual subscriptions to £23,000 ($66,000). At the end of that year, a 5-year program of research, providing for the establishment, equipment, and staff of a permanent headquarters, was submitted to DSIR. The program was accepted and endorsed, as a result of which WRA was admitted to the grant-aided scheme, with a grant extending from 1959 to 1964, under the previously mentioned conditions pertaining to grants.

Council

The WRA Council of thirteen is drawn predominantly from the administrative personnel of member organizations. It includes, however, representatives of DSIR and the Ministry of Housing and Local Government, which is responsible to Parliament for environmental health and, consequently, for water supply. The council represents the broad interests of the association's membership, and its function is to determine general policy, to secure finance, and to supervise expenditure. It has powers to co-opt four additional members.

Research Advisory Committee

The council is advised in matters of research by a committee, whose chairman has a seat on the council. The committee is made up predominantly of water engineers and water chemists of member organizations, nominated in part by the British Waterworks Association and in part by the Institution of Water Engineers. The committee also includes representatives nominated by research associations working in fields related to WRA activities. In this category are, among others, representatives from the Freshwater Biological Association, the British Hydromechanics Research Associ-

ation, the Water Pollution Research Laboratory, and the engineering and scientific department of the Ministry of Housing and Local Government. This representation insures that all aspects of research proceeding in kindred fields are taken into account in formulating WRA's research program, and makes certain that duplication of effort is avoided. There are at present sixteen members serving on the advisory committee.

Membership Classifications

Ordinary members comprise persons or corporations carrying on business in the supply, production, distribution, or marketing of water, machinery, appliances, accessories, or material to be employed in the supply of water. Such members have the right to vote at general meetings. The voting power of a member is related to the amount of his subscription. *Associate members* are those who are members of any class of the Institution of Water Engineers. This membership also includes scientific workers, journalists, and others connected with the water industry or any allied trade. *Delegate members* are elected as representatives of other associations established for kindred purposes. *Honorary membership* is subject to nomination by the council and election by the association in general meeting.

Subscriptions

For the purpose of levying subscription rates, the specification of groups within the foregoing classes of membership is straightforward in the instance of water organizations having interests completely identified with those of WRA. For others, special considerations to meet particular conditions are often necessary before an appropriate subscription figure can be reached.

On joining, every member agrees to subscribe initially for a period of 5 years from the date of his election. His membership thereafter is on a year-to-year basis. He may withdraw from the association by giving notice in writing at least 6 months before the expiration of any financial year and also before each and any subsequent year for which he has guaranteed to subscribe on election.

Water suppliers providing water to individual consumers (domestic or industrial) subscribe annually a sum equal to 0.1 per cent of their water revenue of the previous financial year. This revenue excludes rents for meters and receipts for supplies of water in bulk. The maximum subscription is £4,200 ($12,000); the minimum, £26/5/0 ($75). Water suppliers providing water to other water authorities (wholesale or bulk supply) subscribe a sum not less than £26/5/0 ($75), subject to the discretion of the council.

Corporate bodies other than water suppliers—these include industries concerned with the supply of goods to the water industry or with the processing of water for their own purposes—subscribe at a rate similar to that of water suppliers, except that their revenue from water is now interpreted as the gross turnover of their business or of that part of their business activity which qualifies them for membership. In this regard, the council has discretionary powers, for frequently it is necessary to agree on a figure. Consultants in water supply qualify for membership within this group; their subscription is based on the number of partners and supporting staff in the consulting firm. Associate members are admitted at an annual subscription of not less

than £5/5/0 ($15), at the discretion of the council.

These subscription rates came into force in 1959 and represented a doubling of the rate that had applied since the founding of WRA. Rates were increased to enable WRA to take full advantage of the terms of a grant offered by DSIR in that year, in support of its research program. The terms were for a 5-year period and comprised an annual block grant of £15,000 ($42,860), provided that £30,000 ($85,720) of membership income was obtained. An incentive grant was also offered at the rate of £80 ($229) for every £100 ($286) of membership income more than £30,000 ($85,720), up to the limit of £12,000 ($34,286) of grant. It was thus possible for WRA to obtain £27,000 ($77,140) of government grant, if it could obtain from its members £45,000 ($128,580) annually.

Present Membership and Staff

In April 1960, there were 225 water suppliers in the ordinary membership of WRA, a number slightly less than the 1958 figure, because of the amalgamations that had taken place in the interval. There were also 24 industrial firms representing, for example, water treatment plant and chemical suppliers, metal pipe and fittings and plastic pipe manufacturers, and paper mills and the nationalized electricity board. There are no members in any other class.

Table 2 shows the water supplier portion of membership by size distribution, size referring to the average daily output. There are approximately 870 water suppliers in the United Kingdom. Although numerically only a quarter are members, the quantity of water supplied by them, and on which is based their financial contribution to the association, is approximately 75 per cent of all the water distributed in the country. The small number of members distributing less than 2 mgd is partly explained by the existence of a minimum rate of subscription.

Of each 100 member water suppliers, 52 represent the water departments of municipal authorities; 11, urban and rural district councils; 17, water boards and water committees; and 20, statutory water companies. Approximately half the financial contributions from these sources come from municipal authorities, a little from urban and rural district councils, and a quarter each from water boards and statutory water companies. Water suppliers provide 95 per cent of WRA's membership income.

There are 23 people on the staff of WRA, including graduate scientists

TABLE 2

Size Distribution of Water Suppliers With Regard to WRA Membership

Daily Output *mil gal*	All Suppliers	WRA Members	Membership %
335	1	1	100
90	2	1	50
60–50	2	2	100
50–40	1	1	100
40–30	7	5	70
30–20	5	5	100
20–10	32	29	90
10–5	50	45	90
5–2	114	84	74
2–1	95	34	34
1–0.5	167	15	9
0.5–0.2	152	3	2
0.2–0.1	116	0	0
0.1–0.01	72	0	0
<0.01	54	0	0
Total	870	225	26

qualified in chemistry, physical chemistry, physics, botany, and hydrology.

Present Research Program

In formulating the initial research program, the Research Advisory Committee chose to concentrate on a small number of projects, consistent with WRA's limited facilities and financial resources. These projects offered promise of producing useful research results, within a reasonable period of time, that could be used by association members to economic advantage without too much difficulty.

Four divisions were established. The nature of their work and the results achieved so far will be described separately. The titles of technical reports circulated to members indicate the general range of investigations to date:

1. A Survey of Existing Instruments for the Detection of Leaks in Water Mains and Service Supply Pipes
2. A Note on the Treatment of Aggressive Waters by Aeration
3. The Coventry Process of Water Purification
4. The Effect of Ultrasonic Radiation on Gas Vacuoles in Blue-Green Algae
5. Air-Entraining Vortices in Reservoir Draw-Offs
6. A Comparison of Noise From Leaks in Polythene and Iron Service Pipes
7. The Response of Electronic Water Leak Detectors to a Leak Noise
8. The Absorptiometric Determination of Aluminum in Water
9. The Sources of the Vibrations Generated by a Leaking Water Pipe
10. Present Knowledge Concerning the Mechanical Properties of Polythenes Used in Water Supply
11. An Electro-Acoustic Instrument for the Rapid Location of Underground Water Leaks
12. The Theory of the Coagulation Process of Water Treatment—A Review
13. Present State of Standards for Plastic Water Pipes—A Review
14. The Effect of pH on the Coagulation of Dilute Mineral Suspensions With Aluminum Sulfate
15. The Isolation and Examination of the Fine Suspended Solids From Nine English Rivers
16. The Mechanical Properties of Geon RA.170 High-Impact PVC Tube for Water Supply.

Research Division Studies

The WRA Research Division is concerned primarily with a scientific study of water treatment. It is engaged in a long-term investigation of the fundamental processes of coagulation and flocculation.

The first task was the development of methods of assessing the importance of the large number of physical and chemical variants involved. Some of these have been studied with the use of a modified version of the jar test technique. Suspensions of pure clay minerals in distilled water, containing added electrolytes to give known ionic compositions and pH values, have been used as synthetic waters, and the application of aluminum and iron salts to the coagulation of these systems has been studied. The effects due to the coagulation properties of these chemicals, as distinct from those arising from their acidic nature, have been separated. Similar studies have also been made with the deposits, present in semicolloidal form, collected from selected English rivers by centrifugal extraction. Valuable results have been

obtained from this work, for these deposits, themselves identified by x-ray analysis, have been found to respond to coagulation in precisely the same way as the pure clay minerals. Moreover, the organic matter with which the deposits are inevitably associated appears not to affect their coagulation markedly. Indeed, an important conclusion of this work is that the coagulation process can be regarded as largely independent of the nature of the turbidity. As a result of these findings, further work is now being directed to a study of the coagulant itself and the conditions necessary for optimum effect.

Sufficient progress has now been made in the study of the removal of turbidity from raw waters to permit a start on the study of the removal of dissolved color. Methods are under development for the removal of this dissolved and semicolloidal organic matter in the laboratory, with the object of obtaining it in concentrated form. The effect of this color essence on the coagulation process can then be studied with the techniques already adopted for the study of turbidity removal.

The economic significance of these investigations to the British water industry is certain to be very great. Improved techniques are likely to result in the use of smaller quantities of chemicals, and, much more important, capital savings will be realized from an increase in the output from existing plant. An improved coagulation technique in use by one of the association's members has already resulted in the possibility of a throughput from a plant designed for 6 mgd being raised to 10 mgd, with a saving of capital expenditures of more than £100,000 ($286,000). The eventual determination of *why* and not merely *how* a water treatment process works will permit an estimate of the efficiency of the process and will lead to the development of higher efficiencies. Practical plant experimentation by water chemists will be made more purposeful if founded on the results of basic research.

Technology Division Studies

The WRA Technology Division is at work on two major projects, one relating to the detection of leaks from undergound water mains and the other to the application of plastic materials for use in water distribution.

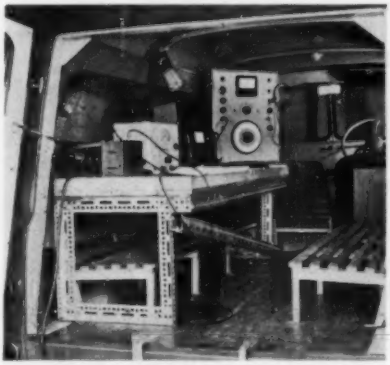

Fig. 4. Mobile Laboratory for Leak Noise Analysis and Recording

An electronic detector that can be used by unskilled labor for rapid surveys is now being perfected.

Leak detection. It is generally accepted that approximately 10 per cent of all the water distributed by water suppliers in Great Britain is lost because of leakage at joints and fractures in water mains and associated service pipe. This percentage is known to be low compared with that of many other

countries. A reliable method of leak detection is not known to the water industry; the time-honored method consists of listening to the ground surface above pipe with the use of wooden sounding rods (stethoscopes). Indirect evidence is also available from metering techniques.

The association's investigations are designed to: (1) develop a more satisfactory instrument for detecting the sounds generated by leaks and heard by sounding the ground above the main or service pipe; (2) determine the true source and character of the sound from which a novel method of detection might be devised; and (3) examine the possibility of leak detection by other means. A mobile laboratory (Fig. 4) has been used for the analysis and recording of the noise of leaks. An electronic detector has now been constructed, and field trials with the prototype are underway. Though this instrument shows no better discrimination than that of the trained stethoscope operator, it can be used by unskilled labor and provides a means of rapidly surveying long lengths of mains to identify points of suspected leakage, these being checked subsequently by traditional means. Additionally, for water pipe of main sizes, ferreting techniques are being examined with a view to their possible adaption for leak detection.

WRA is also engaged in an operational research study of the functioning of a leak detection service. The association is attempting to determine the optimum size of this service, in relation to the size of the undertaking and the pattern of leakage shown by its records over the years. It has been found possible, by making certain assumptions concerning the way leaks develop once they occur, to provide members with a mathematical process by which they can analyze their own data. This process will enable members to determine the cost of an optimum leak detection service in relation to the financial loss from the leakage.

A successful solution to the detection of leakage is regarded as one of the most important objectives of WRA. In Britain, the water industry sells more than £70,000,000 ($200,000,000) worth of water each year. Because of leakage, the cost to the consumer is probably £7,000,000 ($20,000,000) more than it need be. This value is equivalent to a loss of 150 mgd. A saving of this amount would go far in assisting the industry to meet the present trend of rising demands and enable it to defer additional capital expense otherwise necessary.

Plastic water mains and services. In extensive areas of Great Britain, water mains are laid in ground that is corrosive to iron and steel. In anaerobic conditions, sulfate-reducing bacteria speed up the attack by consuming the products of such corrosion. Protection in the form of pipe coatings or some method of cathodic protection is valuable, but the possibility of constructing mains of noncorrodible materials merits consideration, especially when these can be expected to have such additional advantages as lightness and flexibility.

Owing to the initial technical development of polyethylene in Britain and polyvinyl chloride (PVC) in Germany, predominantly different materials have been used for pipe in the United Kingdom and on the Continent. An inquiry by WRA has shown that about 3,300 mi of polyethylene pipe but no more than 20 mi of PVC are in use. A Dutch research organization has disclosed that only 350 mi of polyethylene

but 2,000 mi of PVC pipe for service connections and 300 mi in main sizes are laid in Holland.

As a result of experience in the use of polyethylene in service pipe sizes already existing in Britain, the association's work is designed to encourage the intelligent use of such materials as unplasticized PVC for the construction of water mains. Its work is designed particularly to make possible a service life of 50 years for these materials, with regard to their characteristics of "creep" under constant stress. In an industry financed largely by the raising of loans by government sanction, it is important to demonstrate that the capital works involved will last out the life of the loans, commonly granted for 30 or 50 years.

Besides the development of accelerated tests of plastic mains, the division's work embraces investigations of jointing procedures, ways of tapping supply pipe, techniques for river and bridge crossings, and guidance in the drafting of standards for these new materials. Without standards, the ready application of new materials by water engineers could not be expected.

Information Division Services

As the main objective of an industrial research association is to contribute to the effectiveness of the industry it represents, it follows that success cannot be insured by the quality of the research alone; results must be appreciated by industry and applied in industrial practice. It is necessary, therefore, to provide such member services as library facilities, information and advisory services, and educational services (staff lectures), in addition to technical bulletins, pamphlets, digests, and newsletters conveying information to the technical man in the industry, in language free from scientific jargon. Training schemes can be organized by WRA and run at its laboratories, and, where appropriate, technical staff from member firms can work in the laboratory for a period of time.

Information services, in a broad sense, are used to answer the questions of the general public and organizations outside the industry of a research association, with the object of fostering the industry's trade and reputation. These services are also used to handle technical inquiries—by providing answers to members' day-to-day problems—often initiated by a request for an examination of a defective product, for an explanation of the origin of the defect, and, where possible, for suggestions to prevent the recurrence of the defect. Reciprocal relationships between the information divisions of all research associations are of very great advantage to the members, because of the wide range of industries covered by the research association movement as a whole.

A further service, usually referred to as liaison, provides for visits by selected personnel of the WRA staff to members, first to uncover and solve problems—sometimes on the spot and sometimes after transmission to the association—and second to introduce the association's research to managers, foremen, and other technical staff. The liaison officer is specifically charged with the public relations of the association at the management and technical level.

The Information Division of WRA has a library unit and an information section supervised by an information officer. The division collects scientific information in general and data derived from the water supply field and

research associations to provide a background to the association's own work and to answer members' inquiries. The library is organized not only for the use of the WRA staff but also for its members. The division is responsible for the production of the association's literature, and particularly its technical reports and its quarterly bulletin, *Water Research News*. This quarterly serves not only to keep members informed of the association's activities and to acquaint them with the meaning and significance of research, cooperative and otherwise, but also to establish contact with organizations throughout the world with interests similar to those of WRA. *Water Research News* is mailed regularly to more than 100 other organizations overseas.

At present, the division handles technical inquiries from members and nonmembers at the rate of approximately 200 inquiries a year. For small water suppliers with a limited technical staff, this service is undoubtedly of great value.

A significant part of the work of the Information Division is to supply information for WRA's research and technology divisions. Experimental work should never be undertaken until all previous work in the field has been studied. It is not sufficient to read material collected only from the recognized journals of water engineering and water chemistry published in Britain and abroad. It is usually more important to be aware of scientific research reported, for instance, in the journals pertaining to acoustics, polymer physics, and colloid chemistry, and the research of other scientific disciplines relevant to the projected investigation.

The division's activities seek to impress upon the industry the necessity not only of supporting collective research but also of organizing and reporting experimentation of its own in such a way as to contribute to the research picture of the industry as a whole. Experimentation is of itself not the same as research, but, with the aid of a research association, the investigations that go on daily inside an industry can acquire scientific value. To science, "no" is as much an answer as "yes." An experiment that fails in its intended purpose is still of value if the result is recorded for coordination with the work of others. The research association is available also to insure that investigations by members are planned with a knowledge of previous work in the field and that controls are adapted to insure that results obtained are not merely fortuitous.

Administrative Division

The function of the Administrative Division is to provide for the routine needs of the other divisions. Through it, the director handles membership matters and controls research expenditure.

Future Projects and Developments

Four years after its establishment as an operational unit, WRA is now taking a major step forward. With the certainty of an annual income of at least £70,000 ($200,000) for the next 4 years, it is establishing permanent headquarters on the banks of the Thames at Medmenham in Buckinghamshire. The facilities planned there include a large laboratory for pilot plant experimentation (raw-water supply is from the adjacent river), with supporting technical laboratories and workshop facilities. General chem-

istry, physical chemistry, physics, radiochemistry, and microbiology laboratories are planned, together with a library and information and administrative offices. Sufficient land is available for field work on leak detection, corrosion, plastic pipe, sludge disposal, and for future expansion.

Besides the projects in the current research program, new fields of investigation will include studies of filtration processes, the disposal and reclamation of sludge, the speeding up of bacteriologic examination, an investigation into algal control and taste and odor problems, the development of existing methods of chemical analyses, and the formulation of new methods. WRA plans to participate also in certain aspects of hydrologic problems relating specifically to underground pollution and to land utilization of upland catchments. An expansion of the association's information and advisory services, together with the provision of mobile teams for liaison work at member establishments, is provided for. The existing staff is expected to be increased to approximately 50; it will then include, at graduate level, five physicists, three chemists, three chemical engineers, two hydrologists, one microbiologist, one botanist, and one mathematician.

Cooperative research to be successful must be conceived on a grand scale. Research associations that have not seen and acted on this vision lead stunted lives, cramped by their own usefulness. *Ad hoc* inquiries, trouble-shooting investigations, and hand-to-mouth acceptance of immediate problems occupy the time and effort of these associations to the exclusion of their properly scaled research function. An industry such as water supply, largely noncompetitive within itself, is ideally constituted to receive, adapt, and benefit from the concept of cooperative research. It is vital that, at the outset, the function of the association be properly understood by the industry. It is imperative that the industry come to regard the research association as an integral part of itself, not an organization outside of it, unaware of the industry's needs. It is vital that the association plan its member services with this in mind and also establish that research is the province of the industry itself, not work to be subcontracted to outside organizations. The research association has an important role, but it is essentially an auxiliary one. Science and industry, research and production, must not be divorced. Investigations must be carried out alongside the day-to-day work of the industry, because it is there that the fruits of research must in the end manifest themselves. Research would otherwise become academic and its results inaccessible to members having no qualified scientific staff.

Member services and, particularly, the information service must gather information not only from all sources of knowledge outside the industry, but also from within the industry itself. For the future, WRA confidently anticipates that its members will come to regard it as a repository of experience and know-how in the water supply field, as well as a focal point for research into water problems.

Eventually, WRA expects to broaden its membership and hopes to include river boards, land drainage and irrigation authorities, hydroelectric boards, and industries concerned with steam generation and other processes using water. It anticipates further support for its work from water suppliers and users, abroad as well as at home.

It is clear that much of the association's future work will have an application outside Britain. Just as it finds coordination of its work essential with that of its own membership and with that of organizations working in related fields in Britain, WRA will need in the future to establish closer cooperation with similar organizations abroad.

Conclusion

In Britain, the demands made on the water industry by the rapidly developing technology of industry generally, and by the new industries that have come into being over the last 30 years particularly, have not produced so immediate a response as in the United States. The application of new technologies and scientific disciplines to the American water industry has been swift, and the high standard of technical papers presented in the JOURNAL bears witness to this.

It is to be hoped, however, that the concept of cooperative research, on which the British research association movement is conceived, will stimulate the American water industry to consider whether its own technical activities might profitably be coordinated more closely in the future. Research associations are said to be characteristically British in concept and function. It would be interesting to learn how far this pattern of cooperation could be applied to American industry.

Research in Canada—*Albert E. Berry*

A paper presented by Albert E. Berry, Gen. Mgr., Ontario Water Resources Com., Toronto, Ont.

The very close relationship between the United States and Canada, with regard to water supply practice, makes for a common interest in research programs in this field. There is an increasing awareness in Canada of the need for research. Although research facilities are available, they are inadequate, and more cooperation and coordination are needed among research workers. Efforts are now being made to correct these conditions.

Present Status and Attitudes

Administrative organizations in Canada are different from those in the United States and elsewhere. The very large territory of Canada occupied by only 17,000,000 people does not have the cohesiveness and the multiplicity of problems encountered in more populous countries. Water utilities and supplies are supervised by the ten provinces. Each has a department of health and facilities for the control of public water supplies. In Ontario, new measures are in effect. There is also a Department of National Health and Welfare, with headquarters at Ottawa, Ont. These agencies constitute a framework within which substantial research in water supply may be expected. Other agencies can be made available to aid in this activity. Although no central body is charged essentially with water research, there are opportunities for joint efforts.

The importance of water research is recognized in Canada. It is realized that the research should cover a wide field and should not be limited to laboratory studies. Programs must be directed to serve the needs of water

systems in general, including facilities for treatment and distribution, resources, and all phases of securing and delivering water to the consumer. Programs of research must be closely related to practices in the field. Hence, there is an appreciation of the need for the closest liaison between research and control or enforcement agencies. The two are so interrelated that coordination of efforts is desirable. There is further recognition that a full-scale research program must embrace the skills and knowledge of many professions, such as engineering, medicine, chemistry, biology, physics, statistics, and education. The importance of collecting and distributing information on water supply practice is considered a part of this program. These are only some of the viewpoints on research, but this basic attitude is essential if much is to be accomplished.

Past Accomplishments

Past accomplishments in research do not necessarily indicate what may be expected in the future. Previous experience, however, serves effectively as a foundation for further research. In Canada, contributions have been made even though research facilities have been limited. Most of the research has been confined to laboratory work, in which the health departments and water plants have been the active participants. The provinces of Quebec and Ontario have, through their laboratories, made notable contributions. The McCrady project in Quebec on the most probable number in water bacteriology and the various contributions from the experimental station of the Ontario Department of Health should be mentioned. At the municipal level, the work of Howard at Toronto has shown what can be done. As research facilities become more nunumerous, more contributions can be expected.

Research Facilities

Research programs must always be directly related to available facilities and personnel. In Canada, a number of establishments are equipped for adequate research; others can be provided with more equipment without too much difficulty. The problem then becomes one of making the maximum use of all facilities.

In the past, the health departments of the various provinces have provided facilities for research, although this was not their main function. Universities have not yet taken a leading part in research work, but it is believed that their potentialities in this field are great. The distribution of 35 universities and colleges throughout Canada provides an opportunity for widespread use of their facilities.

For several years, the Department of National Health has made available grants for public health purposes. Some of these have been available for research. If the administration can be convinced of the value of water research in relation to public health, these grants can be made available to the water supply field.

Municipal water utilities have always offered opportunities for research. This is especially so in the larger cities equipped with laboratories and other facilities for experimental studies. There are a number of well equipped laboratories at water plants, and trained personnel are available who are interested in finding the answers to current water problems.

In addition to the foregoing, a number of research organizations are available to carry on research projects.

The National Research Council at Ottawa has a highly trained staff of research specialists who have worked on problems of water supply and whose further cooperation can be expected. The Ontario Research Foundation has an extensive program at the provincial level. Other organizations that can be depended on are:

1. British Columbia Research Council
2. Saskatchewan Research Council
3. Research Council of Alberta
4. Nova Scotia Research Foundation
5. New Brunswick Department of Industry and Development
6. Technical Information Services of the National Research Council at Winnipeg and Montreal.

Industry has many research facilities. Although these are not intended to be used primarily for water research, it is feasible for many of them to be utilized in some of the programs. Industry has shown a keen interest in water supply problems, and its support of programs pertaining to the national welfare shows promise of its cooperation in the field of research. Similarly, the manufacturers of process equipment for water, sewage, and industrial wastes are always ready to provide assistance and to enter wholeheartedly into any beneficial programs.

Mention should be made of the facilities now available through the Ontario Water Resources Commission (OWRC). In 1957, OWRC took over from the Provincial Department of Health the responsibility for supervision of public water supplies. In addition, OWRC, under agreements with municipalities, undertakes to design, build, finance, and operate water and sewage works. Since this program was initiated 3 years ago, 117 agreements have been made for an expenditure of nearly $50,000,000. A total of 52 projects are now completed and in operation.

An important part of the OWRC program is the new laboratory and research station now being put into service. The station will be well equipped for research purposes and will be staffed by personnel trained in different branches of science. Research work will be closely synchronized with OWRC field activities.

OWRC Program

The OWRC research program is now in its formative stage. Attempts are being made to complete the plans within the next year. The program is being planned on a cooperative basis to give the OWRC staff the benefit of the advice and assistance of workers in the water supply field and related fields. An advisory committee selected from outside the staff will assist the commission in an overall examination of research needs, the subjects to be studied, and other features of the general program. Such advice from public-spirited and experienced persons is sure to be valuable.

Because the research program will cover a variety of subjects, it is intended to utilize committees whose proposals and accomplishments will be reviewed by an advisory committee. Much of the actual research will be carried out in the new laboratory, but the program will be a cooperative one in which other laboratories and research stations will work together. Such directed joint activity can be expected to produce worthwhile results.

The research program will cover more than laboratory techniques and related subjects. It will include all phases of activity pertaining to water supply, as well as other matters embraced in OWRC activities. Sugges-

tions will be obtained from water utility personnel in Ontario and elsewhere. By joint planning, it is anticipated that research facilities of universities, departments of health, and industry can be coordinated to work to the best advantage.

Summary and Conclusions

In Canada, the opportunities for research on water problems are now most promising. Much has been accomplished in the past. Facilities for research programs are available from many sources. The new OWRC laboratories, which will act in cooperation with water plants in Ontario, are a valuable addition to these facilities. At the present time, there is also a keen appreciation of the place for research in the water supply field. By joint action, under coordinated programs between water supply personnel and those in other disciplines, the prospects for accomplishment are encouraging.

Research in the United States—*Harry A. Faber*

A paper presented by Harry A. Faber, Research Grants Coordinator, Eng. Resources Program, Div. of Eng. Services, USPHS, Washington, D.C.

Research has often been described as the most vital activity in the world today. Certainly it is a rather new and rapidly growing activity that, in the United States, has developed mostly since World War II. The rapidity of this growth is indicated by a National Science Foundation estimate in 1955 showing that of all expenditures for research in the United States since the signing of the Declaration of Independence, 50 per cent of the total was spent in the 5-year period 1950–54. Expenditures for research support were less than six billion dollars in 1954, and have increased to twelve billion dollars in 1960. The support is expected to rise to more than 30 billion dollars by 1970, with expenditures divided approximately equally between government and industry.

An examination of a few facts and figures is needed for a true perspective of the development of water research in the United States. Past history, present trends, and future developments will be discussed briefly.

Past History

Water research in the United States began in 1887, with the operation of the Lawrence Experiment Station of the Massachusetts State Board of Health. Basic studies of water filtration were first undertaken at Lawrence in 1890.[1] The competent engineers, chemists, and biologists at that station made studies of water treatment so fundamental and so well conceived that they are even today counted among the classics of sanitary engineering research. The first two water utility laboratories were established in 1897, in New York City and in Utica, N.Y. By 1917, there were only 83 water utility laboratory installations in the entire United States.[2]

During the 30-year period (up to the beginning of World War I) following the establishment of the Lawrence Experiment Station, a number of testing stations were established by various municipalities. The information gathered by these stations provided fundamental data for the design

of many water treatment plants. A testing station is a working model of a water plant, provided with facilities for measurement and control and for determining the effect of different raw-water and treatment processes. Greeley [3] reviewed the contribution of these to American water supply practice and recorded the date and location of sixteen of the early water-testing stations.

By 1913, USPHS established a stream pollution investigation station in Cincinnati. This was staffed with sanitary engineers, chemists, biologists, and bacteriologists, and was organized to study pollution and natural purification of the Ohio River. In 1948, the Cincinnati laboratory developed into the Environmental Health Center, and, in 1954, it became the R. A. Taft Sanitary Engineering Center. The center is a large laboratory for research, technical assistance, and training in scientific and engineering aspects of environmental health, especially in problems relating to water, stream pollution, air pollution, radiation, and food technology.

During the past 70 years, the contributions made by the Lawrence Experiment Station, municipal testing stations, and USPHS have been of the utmost importance to the water supply industry. Lawrence was the first to provide information for the engineering profession at large. Although it was created to solve specific problems of immediate utility, it early became a training school for research workers, teachers, and practitioners.

The testing stations in various parts of the country not only evaluated local conditions and solved local problems, but also supplied fundamental design data for water treatment plants elsewhere. In more recent years, the technical assistance and training courses given at the Taft Center have contributed widely to the improvement of plant operating practices and to the technical training of personnel.

The period 1917–47 may broadly be considered as one devoted to the consolidation of design data and development of applied research. During this time, many new water treatment plants were built, and equipment manufacturers developed new and improved devices. Applied research was extensively utilized, but few basic research studies were undertaken.

Chiefly from 1947 to the present, a notable development has taken place to support water research projects in universities and research institutions. Federal funds finance the majority of this research, some support comes from states and industry, and, recently, a few municipalities have undertaken to conduct or support research. These municipalities include Chicago, Detroit, Los Angeles, Miami, Philadelphia, St. Louis County, and several cities along the Missouri River.

Chicago has the distinction of starting a research program much earlier and doing more research than any other city. Baylis [4] reported that "research has paid handsomely in the design and operation of the South District Plant . . . advancing our knowledge of water purification and resulting in the production of water of the highest quality." Although most of the studies at Chicago which he referred to are of an applied nature, some studies are quite fundamental, such as the use of the electron microscope for bacteriologic examination and for investigating the coagulation process.

Definitions

The word "research" is commonly used very loosely to mean research and

development. A small portion of total expenditures is going into real research. Although the total sum spent on research and development has increased many times in the last 30 years, the amount spent for basic research has declined from 20 to 10 per cent of the whole. The United States has always been strong in application, development, and engineering, but much less so in basic research—the foundation on which all applications are based.

Research has been defined as a man in a dark room looking for a black cat that may not be there. The description applies most accurately, of course, to basic research. Basic research is needed because it tells something new about nature; developmental work in itself does not. Basic research is not really different from applied research in its real purpose; it is simply applied research for the future.

TABLE 3

Water Supply and Pollution Control Research Projects

Source of Data	Total Number	Annual Total Support *$1,000*	Annual Average Support *$1,000*
1958 US Research Inventory	280	3,500	12.5
1959 USPHS research grants	110	1,306	11.9
1959 Taft Center research projects	23	694	30.2

The scientist usually is concerned with the discovery of new knowledge; in industry, engineering and management officials are concerned with applying new information. Thus, the results of research extend over a broad spectrum of decreasing scientific emphasis—from research through development, design, construction, production, operation and maintenance, application and sales, industrial engineering, and management. It is understandable that the word "research" should mean different things to different people, and generally it is most convenient for those speaking or writing of research to use the word without defining it. In this article, water research includes:

1. *Research, basic and applied:* original investigations or applications of new principles, methods, and techniques
2. *Testing:* experimental comparative studies, with the use of methods and techniques developed by research
3. *Data collection:* comprehensive reports of fundamental data, including analysis and evaluation of variables.

No single source of information has been available, up to the present time, to identify the number and location of active water research projects in the United States. The Engineering Resources Program of USPHS has recently completed a survey of 280 research projects active during 1958 in the broad field of water supply and pollution control. The total support for these 280 projects was approximately $3,500,000. The details of this survey have been published as a "research inventory."[5] Although it is obvious that this first effort to compile a national inventory of research in water and water pollution cannot be complete, it is the best single source of information that has ever been made available.

Statistics

Of the 280 projects listed in the 1958 US Research Inventory, 67 projects may be specifically classified as water research. Appendix A lists each project by location, title of project, investigator, and the source of support. Research in water supply must

be broadly interpreted as research in the related fields of water pollution control. The principles and practices of research in water, sewage, and industrial wastes are so interrelated that new knowledge in any one of these fields is usually applicable to the other two fields. The projects classified specifically as water research principally involve studies of treatment processes, analytic methods, corrosion, algae, and toxicity.

During 1959, the USPHS research grants program supported a total of 110 projects in the field of water supply and pollution control. Of these projects, 26 can be classified as water research. Appendix B lists each project by location, title, and investigator. Also during 1959, the Taft Center conducted 23 projects in the field of water supply and pollution control research, of which 7 can be specifically classified as water research. Appendix C lists each project by its title and the investigator.

Data from the appendixes are summarized in Table 3. Table 4 is an analysis of the research projects classified as water research. These data indicate marked differences between the average amounts of support per year: less support for research grant projects and more support for 1959 projects of the Taft Center. The projects supported by research grants are conducted principally by graduate students in universities, working on a part-time basis and at relatively low salaries. The projects conducted at the Taft Center, however, employ technical personnel on a full-time basis and include costs comparable to those of industrial research projects. The total cost of a research project cannot be directly correlated with the average support per year, nor can the cost be correlated with the ultimate results obtained. The total cost of supporting a research grant project over a period of several years may be higher than that for a project conducted for a shorter period by full-time technical personnel. In addition, the latter may be expected to produce results and publish articles more promptly.

TABLE 4

Water Research Projects

Source of Data	Total Number	Annual Total Support *$1,000*	Annual Average Support *$1,000*
1958 US Research Inventory	67	1,063	15.9
1959 USPHS research grants	26	355	13.6
1959 Taft Center research projects	7	221	31.5

TABLE 5

Water Research Technical Personnel

Source of Data	Total Number	Equivalent Full Time	Average Full Time
1958 US Research Inventory	280	140	2.1
1959 USPHS research grants	109	55	2.1
1959 Taft Center research projects	13	15	2.1

Table 5 shows the numbers of research personnel involved in water research projects. As the majority of these research projects are conducted by technical personnel or university graduate students working part time, both the total number of personnel working on research projects and the equivalent full-time figures have been reported. The average full-time tech-

nical staff is approximately two persons per project for projects in the 1958 US Research Inventory, for research grants projects, or for research projects at the Taft Center.

The cost of research personnel is rising steadily. The simple law of supply and demand dictates such an increase in costs, and there is no foreseeable prospect of either a relative increase in the supply of, or a lessening in the demand for, personnel. There seems to be no question that the first place to control research costs is in the hiring of personnel. The least costly research will be done by the best men. In industry, the national average capital investment for a research worker today is approximately $22,000. It should be kept in mind that the production units of research are people, as opposed to other operations in which machines are the producers and individuals are the intelligent manipulators of the machines. The product of manufacture comes from a machine; the product of research is an idea that comes directly from the mind of the researcher.

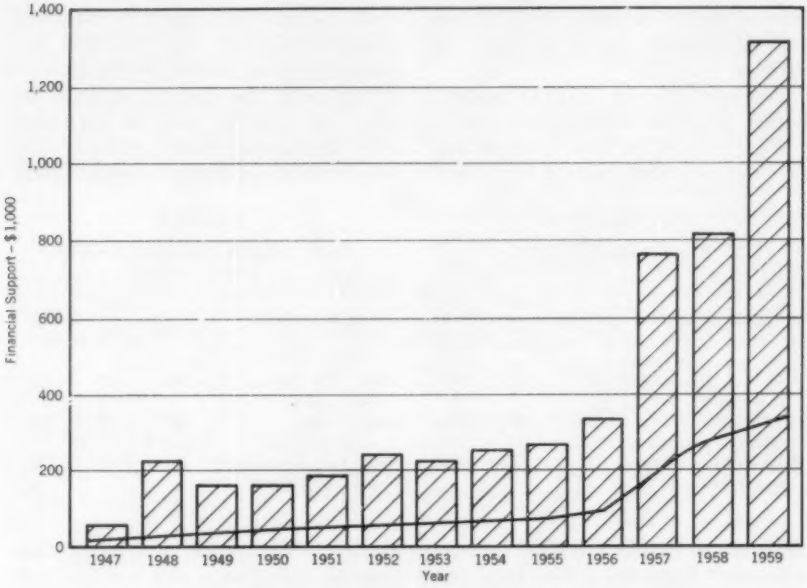

Fig. 5. USPHS Support of Research Grants

Striped bars show the support of all water supply and pollution control projects. The solid curve, representing support for water research only, is approximately 25 per cent of the total.

Table 6 analyzes the 67 water research projects reported in the 1958 US Research Inventory as they relate to the interests of the four functional divisions of AWWA. The data indi-

cate that 16 projects may be classified as of primary interest to the Resources Division, 42 to the Purification Division, 7 to the Distribution Division, and 2 to the Management Division. The table also shows the source of support for all 67 projects, again in relation to the interest of each of the divisions. It will be noted that more than 50 per cent of the support of projects is provided by federal funds, and that the remaining projects are divided almost equally between state, local, and industrial sources of support.

Figure 5 shows the growth of the USPHS research grants program that supports projects in the broad field of water supply and pollution control, from the inception of the program in 1947 through 1959. The research grants projects that may be classified as water research receive approximately 25 per cent of the total support. This was the same general percentage indicated in the 67 projects of the total of 280 in the 1958 US Research Inventory. The source of support for the 67 water supply research projects reported in the 1958 US Research Inventory is shown in Fig. 6. The relationship of these projects to the four divisions of AWWA is shown in Fig. 7.

TABLE 6

1958 US Research Inventory, Water Research Projects

Support of Projects	AWWA Functional Divisions				Total No. of Projects
	Resources	Purification	Distribution	Management	
Federal	7	24	3	1	35
State	6	3	0	0	9
Local	0	7	2	1	10
Institution	0	2	0	0	2
Industry	3	5	2	0	10
Private	0	1	0	0	1
Overall total	16	42	7	2	67

Project and Program Research

Broadly speaking, there are two general types of water research: project research and program research. Water research, as defined in this article, is essentially project research. The program type of research relates principally to the research responsibilities of federal and state agencies in problems of water supply and quality. There are also many instances of combined efforts among federal agencies in securing data or solving problems of mutual interest in the fields of water supply and pollution control.

The Department of the Interior, Department of Commerce, and the Department of Health, Education, and Welfare are the principal federal agencies engaged in basic-data studies. Among the facts needed in this field are those concerning regional and local water supplies which involve variables of stream discharge, storage, and movement of ground water, mineral concentrations, and similar matters. The task of collecting and analyzing the basic

data is both time consuming and costly, but to proceed without this information can be far more costly—if not, indeed, tragic. It has been stated by Aandahl [6] that there is a variety of water problems unique to each region, state, and locality, rather than a national water problem.

Hollis [7] has emphasized the need for more precise information regarding the quality of the nation's water resources, how they are being contaminated, by how much, and why. The first blueprint of these conditions is coming from the National Water Quality Network, which was instituted a few years ago by USPHS. This operation is maintained and run jointly by the federal government and state and local agencies. Approximately 70 sampling stations of an anticipated total of 250 have been established at a number of watercourses to test for radioactivity, plankton, coliform organisms, and organic chemicals, and to carry out a number of biochemical, chemical, and physical measurements.

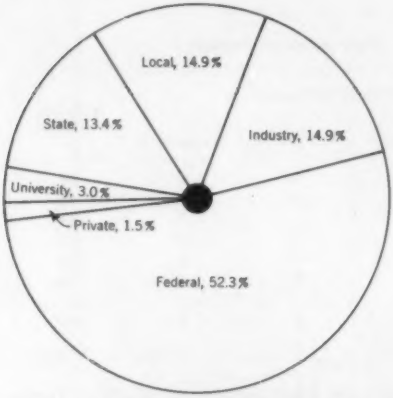

Fig. 6. Source of Support for Water Research Projects

Data refer to the 67 water research projects reported in the 1958 US Research Inventory.

Published Research

After new knowledge is gained in water research, it has value only to the extent that it is distributed to those who can use it. The reports published in technical journals and conference proceedings provide the principal means for the exchange of information. As research grows, so must the technical literature reporting its results. To avoid duplication of original work, scientists must be aware of what others have done and must, today, examine an increasing volume of literature.

The Taft Center is one example of a source of increasing technical publications. From its first publication in 1913 to the present, the scientists and engineers at the center have published

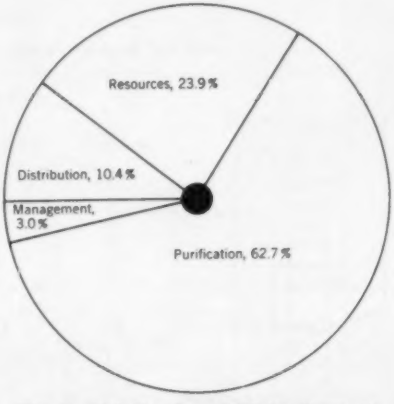

Fig. 7. Relationship of Water Research Projects to AWWA Divisions

Data refer to the 67 water research projects reported in the 1958 US Research Inventory as they relate to the interests of the four divisions of AWWA.

a total of more than 1,150 reports. Even more significant is the rate at which these are being issued, a rate accelerating as rapidly as the research itself. Total publications reached 100 by 1930, 500 by 1952, and 1,000 by 1958. It is well to emphasize, however, that these publications relate to the broad field of sanitary engineering. Among all the publications dated 1959, only fourteen can be considered as reports on water research.

The JOURNAL is the most significant single source of information on water supply research. In order to determine the trend in the publication of such research articles, a survey was made at 5-year intervals from 1914 (Vol. 1) to 1958 (Vol. 50). The total number of text articles and the number of research articles was recorded, and the percentage of research articles was determined (Table 7). When the relationship between total text articles and research articles is examined, it is evident that there has not been a significant increase in the percentage of research articles published in the JOURNAL. The basis for selection of research articles in this comparative study was the definition of water research given earlier. Figure 8 shows the data reported in Table 7.

Water research has certainly increased during the past 70 years—in number of projects, in amount of support, and in terms of research articles published. There is a wide variety of research, testing, and data collection underway, with some investigation being directed toward practically every problem that might be named. These data would be misleading if they gave the impression that *some* research means *adequate* research. The opposite is true. More research is needed on every problem that has been investigated since the inception of the Lawrence Experiment Station 70 years ago.[8] Why are all the "simple problems" that have so long been studied still being worked on today? And why have so many new problems of water research been added in recent years? The answer, of course, is that there will always be a supply of unsolved problems, because each new discovery reveals a host of new problems. Table 8 lists the unsolved water problems of 1887 and those 70 years later.

The table shows that the industry has the same problems, now much intensified, plus many new problems for which research is badly needed.

TABLE 7

Research Articles in Journal AWWA

Year	Journal Volume	Total No. of Articles	No. of Research Articles	Research Articles %
1914	1	62	11	17
1918	5	62	13	21
1923	10	117	16	14
1926	15–16	175	26	15
1928	19–20	190	32	17
1933	25	183	24	13
1938	30	199	32	16
1943	35	244	12	5
1948	40	167	17	10
1953	45	192	26	14
1958	50	288	60	21

Future Needs

Scientists, engineers, and management officials concerned with public water supply are aware of the large gap between what is known and what needs to be known to insure the provision of a safe and adequate water supply in the future. In a communication to the author, Bernard Berger, chief of Water Supply and Pollution Control Research at the Taft Center, has de-

scribed the needs of water quality research:

> The future problems of potable water supply will probably be similar to those of today. However, they will certainly be more difficult, more widely spread, and more urgent. The challenge to research will involve the need for new and better ways to control, remove, or destroy objectionable organic and inorganic solutes and colloids, including viruses. Improvement in methods for controlling motile organisms able to penetrate water treatment plants and infect distribution systems will be a further requirement.
>
> Research on basic principles of separation and purification must be extended. Particular attention should be given to fundamental knowledge of absorption phenomena as a necessary step in the intelligent application of this technique to waters of different character and quality. Such knowledge is needed to improve the effectiveness of coagulation and filtration, and to provide a sounder and more economical basis for removal of persistent organic compounds. The application of strong chemical oxidants to destroy objectionable persistent organics should be explored. Research on the relationship of filter properties to filter performance should be expanded, to define the actual function of filtration and reduce its cost to a minimum.

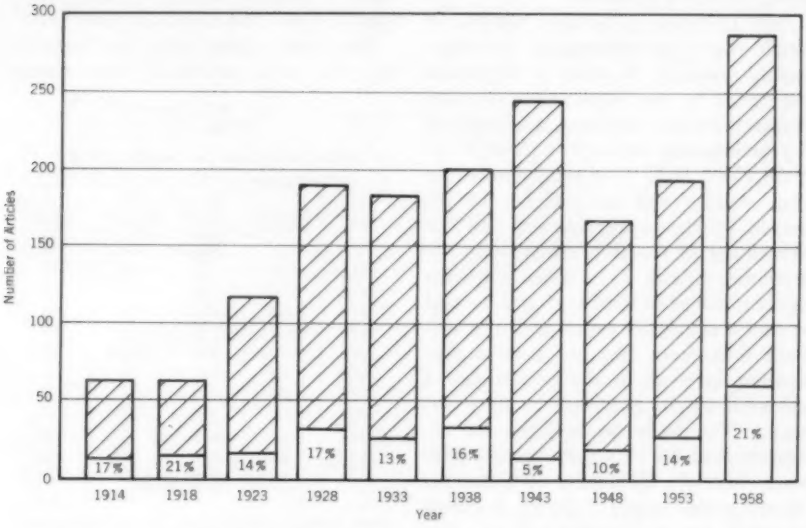

Fig. 8. Percentage of Articles in Journal AWWA Related to Research

The striped bars represent the total number of articles in the Journal. Percentages within the bars refer to water research articles.

Although the tasks of water treatment will probably become more difficult, it cannot be said that the level of current research efforts reflects an awareness of the growing problem. The challenge to the water supply profession may be clearly specified. The general area of the required research effort may be described. An adequate program has yet to be activated.

There will be many other problems. Standards of water quality today are "standards of ignorance." The early concern over water quality related largely to biologic and bacterial contaminants. Waterborne diseases have now been controlled to the point where microchemical and microphysical contaminants cause greater concern. These contaminants include radioactivity and such potentially toxic materials as detergents, insecticides, herbicides, and trace elements that may have a long-term effect on the human system. Very little is known about the physiologic effect of waterborne substances, particularly the new "exotic" substances that are increasingly evident as water contaminants. Water quality must never be taken for granted.

The water supply man of the future will have many new research tools to utilize in producing a safe and adequate water supply. Radioisotope technique, for example, is a new tool developed only within the last 10 years. The radioisotope tracer technique can be useful in determining the behavior and flow rate of water by specific studies. It is applicable for studying the rate of precipitation, characteristics of flow in streams, erosion by running water, characteristics of flow through geologic formations, recharging of aquifers, and the storage and contamination of water supplies. The scientist today has more powerful microscopes and a wide variety of new chemical and physical analytic devices to increase the sensitivity and the rapidity of his examinations. Management also has new tools, including electronic computers, mathematical models for the analysis of systems operations, and even airplane surveys.

The number of water resource agencies and research centers is growing. These will put to work more scientists and engineers who can provide the type of research information that is needed. The trend of federal support for research is increasing, both in terms of research project grants and also in other types of support. These include research fellowships and training grants to recruit needed research personnel, and also construction grants for research facilities to assist in the provision of adequate research centers.

The progress made so far is encouraging. All four divisions of AWWA —Resources, Purification, Distribution, and Management—need to develop and put to use the results of water research. The principal problem concerns the question of whether or not there is now sufficient manpower at work on the research that is needed. Certainly there is no progress without some investment.

TABLE 8

Water Supply Problems in 1887 and 1957

1887	1957
Coagulation	Coagulation
Corrosion	Corrosion
Disinfection	Disinfection
Taste & Odor	Taste & Odor
	Toxicity
	Trace elements
	Radioactivity
	Recovery
	Saline water

Conclusions

Five years have passed since an AWWA Committee on Research Needs,[9] under Martin Flentje as chairman, submitted its report. The committee recommended that the Association actively undertake "the support of research and the training of research scientists and engineers in those areas

of interest to members of the Association," and that it provide financial support for these purposes. At that time, the committee also proposed eight subjects for research and suggested that projects should be activated by the Association. The studies proposed included suppression of evaporation losses; principles of flocculation; removal of detergents; iron and manganese; control of corrosion; water hammer effects; and improved leak detection devices. Although some research is now underway on nearly all of these subjects, and the results of this research will be useful, the problems are far from solved.

More recently, Seeger and Appleyard [10] discussed management concepts of future advancements that they term "blue sky thinking." The authors point out that all of these advancements will not just happen. They recognize that active research projects (not just confined to treatment processes) are needed. They suggest that applied research, adapting processes already developed in other industries, would be of use to water utilities.

It is certain that a great amount of research will be carried on in the United States during the next decade. Ruzic [11] has estimated that during the 1960's approximately 160 billion dollars will be invested in research and development. What this means is that the amount of money and human energy to be expended in the coming 10-year period will be equivalent to, or greater than, all that spent on research and development since the United States came into being.

How much money and manpower will be spent on research and development in the water supply industry? Data have been presented in terms of a 1958 US Research Inventory—recognized as incomplete—suggesting that the total present support of water research in the United States is nearly $1,700,000 per year. This convenient figure is proposed because it is equivalent to 1 cent per capita per year. It is not very much.

Research is recognized by most businesses as necessary and profitable. It represents an investment in dollars and manpower to develop fresh approaches, new ideas, and new techniques. A research program to be most effective should be designed to solve problems in the specific field it is to serve. Needed are ideas, men, money, and facilities.

The American water supply industry has provided very limited funds for the support of research. Certainly the industry itself is most qualified to identify its research needs and establish priorities for their study. The industry can also best integrate and coordinate the overall effort in this direction. It should support research through its own resources and should see that research information is disseminated to the entire water supply industry.

Industry and government support of research would serve to supplement and complement each other. A research program should be undertaken by the American water supply industry to provide the leadership and support needed for long-range planning.

Acknowledgments

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charts; and Lena J. Bryson, secretary, who prepared the article.

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APPENDIX A

Water Research Programs: 1958 US Research Inventory Report

Arkansas

University of Arkansas, Fayetteville. Variables Affecting Efficiency of Coarse-Grained Water Filters. L. R. Heiple. Support: Winthrop Rockefeller.

California

California Institute of Technology, Pasadena. Resuspension of Flocculent Solids in Sedimentation Basins. A. C. Ingersoll. Support: federal research grant.

University of Southern California, Los Angeles. Chromatographic Assay of Extracellular Algal Metabolism Products. R. C. Merz. Support: federal research grant.

Connecticut

Yale University, New Haven. Estimating Yields of a Reservoir on a Digital Computer. E. L. MacLeman. Support: MIT Computer Center and New Haven Water Co.

Yale University, New Haven. Lake Whitney Sanitary Conditions Related to Lab Examinations. E. L. MacLeman. Support: New Haven Water Co.

District of Columbia

Georgetown University, Washington, D.C. Radioactive Isotope Technique for Detection of Coliform Organisms. W. C. Hess. Support: federal research grant.

Florida

University of Florida, Gainesville. Comprehensive Study of Water Coagulation. A. P. Black. Support: federal research grant.

University of Florida, Gainesville. Ion-Exchange Resins to Remove Fluo-

ride Ion From Drinking Water. A. P. Black. Support: federal research grant.

Illinois

Chicago Department of Water & Sewers, Chicago. Coagulating Water With Ferrous Sulfate Liquid From Steel Mills. J. R. Baylis. Support: local.

Chicago Department of Water & Sewers, Chicago. Corrosion of Cast-Iron Water Pipe. J. R. Baylis. Support: local.

Chicago Department of Water & Sewers, Chicago. Detection of Coliform Bacteria With the Electron Microscope. L. E. Scarce. Support: local.

Chicago Department of Water & Sewers, Chicago. Sand Bed Studies and Gravel Movement in Filter Bed Maintenance. J. R. Baylis. Support: local.

Chicago Department of Water & Sewers, Chicago. High-Rate Filtration. J. R. Baylis. Support: local.

Chicago Department of Water & Sewers, Chicago. Filtered Water Coagulated Material Detection by Membrane Filter. J. C. Vaughn. Support: local.

Chicago Department of Water & Sewers, Chicago. Monitoring Water for Radioactivity. J. R. Baylis. Support: local.

Chicago Department of Water & Sewers, Chicago. Ridged Gelatinous Coating in Water Pipe Causing Friction Loss. J. R. Baylis. Support: local.

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Illinois State Water Survey, Urbana. Reservoir Sediment and Watershed Factors at Springfield Plain. J. B. Stall. Support: federal and state.

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Illinois State Water Survey, Urbana. Ground Water Occurrence, Yield, and Movement in American Bottom. H. F. Smith. Support: state.

Illinois State Water Survey, Urbana. Ground Water Recharge in Peoria. R. H. Harmeson. Support: state.

Illinois State Water Survey, Urbana. Loss of Carrying Capacity in Water Mains Due to Water Quality. T. E. Larson. Support: federal research grant.

Illinois State Water Survey, Urbana. Mounts for Low-Level Radioactivity Counting in Water Solids. T. E. Larson. Support: state.

Illinois State Water Survey, Urbana. Study of Surface Precipitation Using Radar Instrumentation. Glenn Stout. Support: US Army Signal Corps.

Indiana

Purdue University, Lafayette. Effect of Disinfection Dosages on Coal-Tar–Lined Cast-Iron Pipe. H. R. Wilke. Support: J. B. Clow & Sons.

Iowa

Iowa State College, Ames. Diatomite Filtration of Municipal Water Supplies. E. R. Baumann. Support: Iowa State College and Everpure, Inc.

Iowa State College, Ames. Superchlorination-Dechlorination Studies on Small Water Supplies. E. R. Baumann. Support: Iowa State College and Everpure, Inc.

Kansas

Kansas State Board of Health, Topeka. Sources and Seasonal Variations of Nitrates in Water Supply Wells. D. F. Metzler. Support: federal research grant.

Kansas State Board of Health, Topeka. Coliform Organisms and Enterococci as Indices of Water Quality. Cassandra Ritter. Support: federal research grant.

University of Kansas, Lawrence. Synthetic Detergent Removal in Municipal Water Supplies. R. T. Page. Support: University of Kansas.

Maryland

Johns Hopkins University, Baltimore. Removal of ABS From Potable Water by Treatment Modification. C. E. Renn. Support: AASGP.

Johns Hopkins University, Baltimore. Improvement of Molecular Membrane Bacteriological Techniques. C. E. Renn. Support: Salem-Brosius, Inc.

Massachusetts

Massachusetts Institute of Technology, Cambridge. Corrosion Control in Potable Water Systems. Rolf Eliassen. Support: American Iron & Steel Institute, AWWA, and John B. Pierce Foundation.

Michigan

Michigan State University, East Lansing. Toxicity of Cadmium and Hexavalent Chromium in Water Supplies. R. U. Byerrum. Support: federal research grant.

Michigan State University, East Lansing. Protective Coatings in Water Distribution Systems. R. F. McCauley. Support: federal research grant.

University of Michigan, Ann Arbor. Drought Flow Characteristics of Michigan Streams. C. J. Velz. Support: state.

Wayne State University, Detroit. Determining Radioactive Isotopes in Water and Sewage. R. B. Hahn. Support: federal research grant.

New Hampshire

University of New Hampshire, Durham. Enterococci as Indicators of Pollution Using Membrane Filter. L. W. Slanetz. Support: federal research grant.

New York

Columbia University, New York. Dispersion in Flow-Through Porous Media. Eugene Simpson. Support: federal research grant.

Manhattan College, Riverdale. Statistical Analysis on Drought Flows in New York State. Manhattan College. Support: state.

Manhattan College, Riverdale. Statistical Analysis of Drought Flows in Rivers of New York State. D. J. O'Connor. Support: state.

North Carolina

University of North Carolina, Chapel Hill. Cholinesterase Activity of Fish Brain Tissue. C. M. Weiss. Support: federal research grant.

University of North Carolina, Chapel Hill. Kinetics and Mechanism of Reactions Involving Chlorine Dioxide. M. L. Granstrom. Support: federal.

University of North Carolina, Chapel Hill. Coagulation of Colloids Having Hydroxyl, Amino, or Carboxyl Groups. M. L. Granstrom. Support: federal research grant.

Ohio

Kenyon College, Gambier. Spectrophotometric Determination of Ions in Wastes and Water. J. M. Pappenhagen. Support: federal research grant.

Ohio River Valley Water Sanitation Commission, Cincinnati. Continuous Recording and Transmission of Water Quality Data. Ohio River Valley Water Sanitation Commission. Support: state.

R. A. Taft Sanitary Engineering Center, Cincinnati. Improvement of Analysis of Organics in Polluted Water. F. M. Middleton. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Significance of Protozoal and Metazoal Organisms in Water. S. L. Chang. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Enumeration of Bacterial Indicators of Contamination. H. F. Clark. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Role of Water in the Transmission of Viral Diseases. N. A. Clarke. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Efficiency of Silver as a Germicidal Agent. C. W. Chambers. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Analysis of Taste and Odor Compounds From Algae and Actinomycetes. C. M. Palmer. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Effects of Impoundments on Water Quality. F. W. Kittrell. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Filtration Experiments for Water Treatment Processes. G. G. Robeck. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Removal of Coliform Organisms in Water Treatment Processes. Graham Walton. Support: federal.

R. A. Taft Sanitary Engineering Center, Cincinnati. Conservation and Reuse of Water. Graham Walton. Support: federal.

University of Toledo, Toledo. Application of Dolomite Lime in the Treatment of Water. R. E. Martin. Support: Finishing Lime Association of Ohio.

Oklahoma

Oklahoma City Water Department, Oklahoma City. Lake Hefner Evaporation Reduction Studies. M. B. Cunningham. Support: state-local.

Oklahoma State Department of Health, Oklahoma City. Isolation of Virus in a Municipal Water Supply Reservoir. F. R. Hassler. Support: federal-local.

Oregon

Oregon State College, Corvallis. Road Building and Logging Effects on Erosion and Sedimentation. R. H. Ruth. Support: Oregon State Forest Service.

Pennsylvania

Mellon Institute, Pittsburgh. Origin of Tastes and Odors in Drinking Water. R. D. Hoak. Support: American Iron & Steel Institute.

Tennessee

Tennessee Department of Public Health, Nashville. Preservation of Enteric Organisms With Chelating Agents. E. L. Shipe. Support: federal research grant.

Texas

Baylor University, Waco. Toxic Properties of the Blue-Green Algae. F. F. Davidson. Support: federal research grant.

North Texas State College, Denton. Chemical and Physical Quality of Lake Texoma Water. J. K. G. Silvey. Support: federal research grant.

University of Texas, Austin. Ground Water Recharge as Affected by Phosphate Solubilities. E. F. Gloyna. Support: industrial organization.

Utah

Utah State University, Logan. Water Supplies and Utilization in Various Utah Counties. J. M. Bagley. Support: state.

APPENDIX B

Water Research Projects: 1959 USPHS Research Grants

California

California Institute of Technology, Pasadena. Characteristics of Flow Through Expanded Porous Media. N. H. Brooks.

California Institute of Technology, Pasadena. The Resuspension of Flocculent Solids in Sedimentation Basins. A. C. Ingersoll.

Stanford University, Stanford. Evaporation Suppression and Effects on Biota. J. B. Franzini.

University of Southern California, Los Angeles. The Chromatographic Assay of Extracellular Products of Algal Metabolism. R. C. Merz.

District of Columbia

Georgetown University, Washington, D.C. Rapid Bacteriological Determinations by Radioisotopic Methods. W. C. Hess.

Florida

University of Florida, Gainesville. A Comprehensive Study of Water Coagulation. A. P. Black.

Illinois

University of Illinois, Urbana. Fundamental Factors in Treatment of Iron-Bearing Waters. R. S. Engelbrecht.

University of Illinois, Urbana. Chromatographic Analysis for Organic Acids in Water. T. E. Larson.

University of Illinois, Urbana. Effect of Minerals in Water on Radioactivity Counting. T. E. Larson.

University of Illinois, Urbana. Analysis of Trace Amounts of Detergents in Water. R. S. Juvet Jr.

University of Illinois, Urbana. Corrosion and Tuberculation in Distribution Systems. T. E. Larson.

Indiana

Purdue Research Foundation, Lafayette. Methods of Analysis for Liquid Chlorine. M. G. Mellon.

Massachusetts

Harvard University, Cambridge. Analytical Procedures for Metal Contaminants. J. C. Morris.

Harvard University, Cambridge. Oxygenation Rate of Ferrous Iron in Natural Waters. Werner Stumm.

Lawrence Experiment Station, Lawrence. Methods for Measuring the Coliform Content of Water. J. A. McCarthy.

Michigan

Michigan State University, East Lansing. Toxicity Studies on Cadmium and Hexavalent Chromium in Concentrations That May Be Expected in Public Water Supplies. R. U. Byerrum.

Michigan State University, East Lansing. Protective Coatings for Water Distribution Systems. R. F. McCauley.

Missouri

Washington University, St. Louis. Characterization of Extracts From the Missouri River. D. W. Ryckman.

New Hampshire

University of New Hampshire, Durham. Enterococci as Indicators of Water Pollution. L. W. Slanetz.

New York

New York University, New York. Quantitative Determination of Uric Acid in Polluted Waters. G. P. Edwards.

North Carolina

University of North Carolina, Chapel Hill. Use of Fish to Detect Organic Insecticides in Water. C. M. Weiss.

Ohio

Kenyon College, Gambier. Determination of Ions in Wastes and Waters. J. M. Pappenhagen.

Ohio State University, Columbus. Fluoride-Triggered Electrode Reactions. William MacNevin.

Pennsylvania

University of Pittsburgh, Pittsburgh. Physiological Aspects of Water Quality. M. A. Shapiro.

Tennessee

Tennessee Department of Public Health, Nashville. Preservation of Enteric Bacteria With Chelating Agents. E. L. Shipe.

Texas

Baylor University, Waco. Toxic Properties of Blue-Green Algae. F. F. Davidson.

APPENDIX C

Water Research Projects: R. A. Taft Sanitary Engineering Center, Cincinnati, 1959

Conservation and Reuse of Water: Evaporation Reduction. S. L. Chang.

Significance of Protozoal and Metazoal Organisms in Water. S. L. Chang.

Evaluation and Improvement of Water Treatment Processes: Fundamental Studies of Chemical Treatment of Water. J. M. Cohen.

Role of Algae in Environmental Sanitation: Algal Growths in Surface Waters. C. M. Palmer.

Role of Algae in Environmental Sanitation: Algae and Other Interference Organisms in Water Supplies. C. M. Palmer.

Evaluation and Improvement of Water Treatment Processes: Small Water Supply Systems. G. G. Robeck.

Evaluation and Improvement of Water Treatment Processes: Analysis of Filter Design Criteria. G. G. Robeck.

Proposal for AWWA Sponsorship of Research

—Thurston E. Larson—

An introduction to a discussion led by Thurston E. Larson, Head, Chemistry Sec., Illinois State Water Survey Div., Urbana, Ill., and Chairman, Research Subcommittee of Committee 1550—Ad Hoc Com. on Review of AWWA Aims and Objectives

A discussion of what has been done and what should be done in research on public water supply problems has been carried on intensively by the Research Subcommittee of Committee 1550—Ad Hoc Com. on Review of AWWA Aims and Objectives, ever since Harry Faber, now a member of the subcommittee, presented his challenging report on the subject last year.[1] Out of this discussion has come a proposal to establish a water research institute as an independent nonprofit corporation in affiliation with AWWA.

In presenting this idea, the subcommittee recognized that the development of an institute would and should take time—several years, in fact—so that the organization would be handled in an orderly manner. It was also pointed out that a designated nucleus of members of AWWA would be best able to handle the organization job.

Although this statement was made, concern has been expressed about the details of development and the magnitude of the proposal. The subcommittee, whose acceptance of the report was unanimous, did not concern itself with development problems, but limited its report to the final objective. Meanwhile, a number of other statements on research have been presented to the Aims and Objectives Committee for consideration, and the present status of this proposal is only that of a subcommittee report. But, because it presents one method of approaching a problem on which the committee would like to have the comment of members, it is presented here in full.

Proposal

It is proposed to establish the Water Research Institute as an independent, nonprofit corporation in affiliation with the American Water Works Association.

Objectives

The objectives of the corporation shall be to contribute to the present and future progress of the water utilities industry—and, inherently, to the public good—by developing a constructive and collective research program and by providing methods of receiving and administering dues, contributions, gifts, and grants-in-aid for the support of the research program.

Purposes

The Water Research Institute shall be organized under articles of incorporation designed to:

1. Promote the stated objectives by encouraging, supporting, and conducting research and scientific investigations in the fields of water resources, transmission, processing, distribution, and management, and by acquiring and disseminating knowledge in relation thereto

2. Receive or acquire by devise, gifts, or otherwise, any money or property, either absolute or in trust to be used, either the principal or income therefrom, as may be directed for the furtherance of any of the purposes

which may be within its corporate powers

3. Purchase, sell, or lease property, real, personal, or mixed, for the benefit of the Institute

4. Create, purchase, hold, and sell patent rights in the interest of the public welfare for inventions, designs, and copyrights, with the right to issue licenses for the exercise of rights relative to said inventions, designs, and copyrights, and to receive payments therefrom and to use and apply all moneys thus received for the fostering and advancement of research and scientific investigations.

Fig. 9. Proposed Organization Chart

The Water Research Institute is proposed as an independent, nonprofit corporation in affiliation with AWWA.

Organization

Membership in the Institute shall consist of affiliate members and sustaining members. Affiliate members shall be the American Water Works Association and others, as may be designated by the Board of Trustees. Sustaining members shall be any qualified public or private water utility, firm, or corporation, or any qualified organization or individual interested in supporting the objectives of the corporation, subject to approval by the Board of Trustees (Fig. 9).

The affairs of the Institute shall be managed by a Board of Trustees consisting of twelve trustees, or such greater or lesser number as may be determined, elected as representatives of the sustaining members of the Institute. The Board of Trustees shall have the power to hold and conduct meetings at times and places as they may think proper, to make policy decisions, to admit members, and to collect and disburse the funds of the Institute.

Officers

A President and Vice-President shall be elected from the membership of the Board of Trustees to perform the duties necessary to these offices. A Secretary-Director shall be appointed by the Board of Trustees, to serve as the Director of the Institute. A Treasurer shall be appointed by the Board of Trustees. The offices of Secretary-Director and Treasurer may be held by the same person. The salaries of appointed officers shall be determined by the Board of Trustees.

Operations

The operations of the Institute to promote the stated research and scientific investigations shall be the duty of the Secretary-Director. The operations include responsibilities for providing secretarial services and maintaining communications among the Board of Trustees, the Executive Council, and

the Advisory Council. The operations also include responsibilities for administration of the actions and plans of the Executive Council.

The Executive Council shall consist of twelve members comprised of six elected representatives of the sustaining members of the Institute, one elected representative of each Division of AWWA, the Secretary of AWWA, and the Manager of WSWMA. The Executive Council shall meet biennially, or more often as necessary, and shall elect a Chairman and Vice-Chairman from its membership.

The Executive Council shall, after consideration of the recommendations of the Advisory Council, determine the appropriate action on all grants or contractual arrangements for research and scientific investigations. The Executive Council shall also have the responsibility for developing long-range planning for the research and scientific investigations of the Institute.

The Advisory Council of the Institute shall consist of twelve members, or such lesser or greater number as may be recommended, appointed by the Executive Council from individuals proposed by the Secretary-Director. Its membership shall be comprised of nationally recognized research authorities, with at least one representative in the fields of geology, engineering, chemistry, bacteriology, biology, public health, and management.

The Advisory Council shall determine the scientific merit of all grants or contractual investigations submitted to it, and shall have the responsibility of assisting the Secretary-Director in preparing his recommendations to the Executive Council.

Committees may be appointed by the Executive Council at the request of the Secretary-Director to assist in special purposes as may be necessary.

Committee

Members of the Research Subcommittee to whom comment on this proposal should be addressed are H. A. Faber, P. D. Haney, S. H. Hopper, A. A. Kalinske, V. W. Langworthy, D. A. Okun, W. B. Schworm, J. K. G. Silvey, Loring Tabor, R. E. Thompson, W. W. Towne, and T. E. Larson (Chairman).

Reference

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Duties and Responsibilities of the Water Utility Manager

William R. Seeger

A paper presented on May 19, 1960, at the Annual Conference, Bal Harbour, Fla., by William R. Seeger, Gen. Mgr. & Chief Engr., Marin Munic. Water Dist., San Rafael, Calif.

BY far the great majority of water utilities in the United States are small organizations in which men rise from positions as operators to managerial positions as a matter of routine promotion, usually without benefit of special training in the field of management. It is to such men that this article is directed. It is hoped that it will help clarify just what it means to be a utility manager, and what a water utility man can do to prepare himself for a position in the management and administrative branches of the industry.

Responsibilities

The responsibilities of the water utility manager are threefold: first, he is responsible to the controlling body of the utility he manages; second, he is responsible to the employees who form the working organization; and third, he is responsible to the community his utility serves. Until recently, these were the only groups with whom the manager dealt directly, but now, in the author's opinion, the manager's responsibility extends to the whole industry. This idea is one of the basic themes of AWWA's Water Utility Advancement Program, whose object is to foster professional advancement of present and potential utility managers. AWWA is tackling one of the most serious problems of the water supply industry, the shortage of enough adequately trained men to manage the nation's 18,000 water systems. Studies have already pointed out the fact that water utilities have fallen far behind other utilities and other industries in providing incentives, training, and opportunities to engineers and other trained people for careers in the water supply profession. The long-range objectives of the Advancement effort are:

1. To provide the tools for self-improvement through education of present and potential water utility managers
2. To improve communication in the water supply field through increased participation of water utility management in AWWA activities
3. To recruit, develop, and retain a professional group of managers through the development of an AWWA personnel service program
4. To develop among community governing bodies suspport for local water utility participation in the Advancement Program and other AWWA activities.

Typical Manager's Day

During a typical manager's day, he may become involved in administrative

problems, personnel problems, the writing of publicity and news releases, the handling of public relations, establishing a planning program for the utility, and, most important of all, the investigation and development of means of financing the operation of the utility. In addition, he may be involved in such things as production, sales, purchasing, or questions of law. He may also be called upon to enter into the public affairs of his community or take on other assignments particularly pertinent to his particular job and area.

Large and Small Utilities

One of the major differences between the manager of a large metropolitan water utility and the manager of a small utility is that in the larger organization the manager acts as the general overseer of the various functions established in the organization, whereas in the small utility he becomes directly responsible for managing the various functions. In other words, the small-utility manager is "chief cook and bottle washer" for everything involving management, and consequently he must have a general, but not necessarily detailed, knowledge of all of the various phases of management. There is basically no real difference between the principles followed in a large organization and those of a small organization, there being only one set of good business principles. The scale of the activity and the number of personnel assigned to the management phase of the organization are the differentiating factors.

Review of Organization

When a water plant operator has been fortunate enough to receive an assignment as a manager of a small utility, probably his first question is, "What do I do to review this organization to see whether good business principles are being followed?" If he has not had specific training in the management field, he may very well ask, "What do I personally do to familiarize myself with the organization?" His first action should be to seek answers to the following questions:

1. Is there a written plan of organizational procedure?
2. Has an organization chart been established, outlining the various business functions carried on by the utility and defining the duties and responsibilities of the various employees?
3. Has an advance-planning program been developed sufficiently so that the utility's needs for the next 20 years are set forth in a workable program?
4. Is there a workable budget to control the financial expenditures?
5. What other administrative controls are in effect?
6. Are the organization generally and the key personnel specifically conversant with the principles of modern business operation?
7. How much does each of the key personnel know about his particular job? Is he sufficiently familiar with it to train a subordinate?

Preparation for Management

For ultimate success in the management field it is absolutely essential that a prospective manager take steps to prepare himself for the work. It is not necessary for him to take a highly technical college course in business management, but he should pursue a program of study and research and

avail himself of various periodicals dealing with management. Much is to be learned, for example, from reading the quarterly bulletins being issued in *Willing Water* as a part of the AWWA Water Utility Advancement Program.

Although help from others is generally necessary, the preparation of a man for successful work in management is largely a matter of self-education. A very brief search will reveal that there are many opportunities offered today in the field of management study. Practically all of the university extension divisions have courses in management, and many local colleges are only too anxious to set up courses in the field of management.

Hopeful prospects for the management field often ask the question, what must a person have or what must he be to become a success in this field? There are, of course, many desirable qualities, but the possession of the four following characteristics go a long way toward promoting a successful management career:

1. General management competence.
2. Ability to understand and direct technical personnel.
3. A normal amount of human intelligence.
4. Capabilities of leadership.

In addition to possessing these four characteristics, in order to increase his broad understanding of his overall functions a manager needs to keep in mind that:

1. His technical ability is of limited help to him except as the management job involves the making of technical decisions.
2. He will find it necessary to balance and blend much new knowledge with his present technical knowledge in order to be a good manager. These new areas necessarily include organization, management, administration, research, finance, production, sales, law, personnel, public relations, public affairs, as well as others that are unique to each business situation.
3. Good management requires the ability to obtain the best utilization of manpower. This cannot be achieved without first knowing both what things really need to be done and how to get maximum output from people.

As a guide to self-analysis of future utility managers, five attributes are commonly accepted as indicative of a good manager:

1. Ability to contact people at their own level and to communicate in fairly friendly attitudes.
2. Ability to delegate responsibility and authority.
3. Possession of basic objectives as guiding rules for organization.
4. Possession of inspiration and ability to develop it in the organization.
5. Readiness to recognize results accomplished by staff and employees.

Principles of Good Management

During the past years, many books, articles, and talks have elucidated what, in the opinion of various authorities, makes up good management. Space does not permit a review of the many varied opinions, nor does the author feel it is necessary; they can all be summarized in the following seven rules of good management practice:

1. Business should be kept on a high moral code.
2. Principles of management should be reduced to writing so that everyone in the organization knows what they are.

3. Opinions should be expressed freely both by management and submanagement personnel.

4. Employees should be kept fully informed at all times concerning activities of the business.

5. Problems should be looked into and sincere efforts made to solve them in accordance with good management practice.

6. The performance of employees should be reviewed and they should be commended for good sincere effort.

7. A realistic promotion and wage program should be established and maintained.

Budgets and Fiscal Planning

A budget is the basic control needed for the operation of any organization. Often when small organizations hear the word "budget" they become unduly fearful, but budgets are merely a method of controlling expenditures as compared to income. In large organizations, preparation of the budget consumes many months. In fact, in the large metropolitan organizations, budgets are worked out in preliminary form a year in advance. Actually, however, a basic budget can be developed on a single page which sets forth on one side the anticipated expenditures to be made and on the other side the anticipated revenues to be received. Of course, much time and paper could be devoted to the preparation of a budget, but if management is fully aware of the need for and value of developing a budget program, the basic objective will have been accomplished.

The mere existence of a budget is not enough to operate satisfactorily; the budget must be coupled with a planned program of expenditures. This again takes the same form as a budget. It can be as short or as complicated as dictated by the complexity and size of the organization. The planning program merely allocates the available monies to various categories of expenditure. Basically, what a planning program will do is prevent overexpenditures.

Under a proper budgetary and planning program, money will often be accumulated from one year's operation during a period of light expenditures and can then be allocated for expenditures during heavy construction years. The absolute necessity for the development of budgeting and planning controls, even if they consist of only two pieces of paper, cannot be emphasized too strongly, regardless of the size of an organization. There must be some type of planned program that can serve as a guide to the annual operations of the utility.

Public Relations and Publicity

Another important item which is essential to the success of any utility is a good, sound public relations and publicity program. This again is primarily the responsibility of the manager. The author believes that one of the manager's most important responsibilities, after planning and financing, is the matter of public relations or, more specifically, community relations. The manager must keep the public informed concerning his utility's operation; it is vital that the public know about the utility's plans, problems, and day-to-day operations.

The manager must remember at all times that a water utility is a service organization and that it is its duty to keep the public informed of its operations and plans. A municipally

owned utility depends upon the public to finance operations. In a sense, the customers are also stockholders in the business. Therefore, a manager must have them on his side, so that they will give him a favorable response when utility improvements are necessary. He may have to win their support of rate increases and of improvement bond issues. Every utility, regardless of how small, should set up a program of public relations and publicity. The energy expended on a good public relations program will pay manifold dividends.

Personnel Administration

One of the most important jobs a manager has is to develop smooth, compatible employee relations. Everyone is aware that a tremendous amount of money is spent by industry on maintenance programs to prevent mechanical breakdowns and to insure continuity of operation. It is only logical that every bit as much effort and care should be expended by management in the handling of its people, who are, after all, a very important part of the productive "machinery" of any organization.

The following ten rules of good employee relations have been evolved from years of practice and study by leaders of thought in this field:

1. Hire employees in a considerate, orderly, and dignified manner; decent treatment evokes decent response.

2. Pay wages based on scales prevailing for similar work elsewhere in the community, with due recognition of the need for providing a healthful and decent living standard.

3. Deal with employees in a manner calculated to bring mutually satisfactory results, whether through collective or individual negotiations. Establish an orderly procedure for prompt and impartial ascertainment, consideration, and adjustment of grievances.

4. Promote workers to better and more responsible jobs to the extent of their capabilities whenever possible and encourage that spirit of incentive found in every self-respecting man.

5. Establish through every possible means the self-respect of workers and make them feel they are part of the team—not just numbers on a time clock.

6. Dispel inaccurate or distorted ideas as to company policies, earnings, and profits by giving the employees frank statements on company problems and aims.

7. Train both supervisors and employees to build up the highest degree of efficiency and incentive.

8. Protect employees by carefully planned and executed safety programs, and advise and educate workers through health and nutrition programs how to build up their stamina.

9. Provide job regularity and security to the fullest extent that economic conditions will allow.

10. Encourage and carefully consider all constructive workshop ideas that employees may advance.

Delegation of Authority

One of the greatest problems to be solved and handled by anyone new to the management field is learning to delegate authority. It is natural for a man to feel that he can do some jobs better than anybody else. It is only with difficulty that he allows someone else to do the job for him. Many people cling to the old adage, "If you want it done well, do it yourself." If a man

is to become a successful manager, attitudes such as this have to change. Many businessmen are rediscovering that one way to get more work done is to delegate. They are recognizing that the higher a man gets up the executive ladder, the more he is judged by his success in directing other people. Delegation is not easy. The idea of handing over to someone else a job one knows he can do perfectly well himself goes against the grain for many people. In addition, the proper steps to take toward decentralization and delegation can be puzzling.

Critics allege that the engineer turned manager often goes right on trying to do everything himself, which is one sure way of hampering the efficiency of any organization. It seems to be particularly true of engineering managers that they find it difficult to give up knowing all that goes on in a given department or section. They seem to shy away from trusting subordinates and letting them go on their own.

A much quoted formula for managerial success is: analyze, organize, deputize, supervise. This formula says much in four words. The big question is how to go about it.

How can a manager train himself to delegate authority properly? It must be remembered that when a man is given new responsibility, management must make it possible for him to accomplish what it wants him to do. This involves the following basic steps:

1. He must be given a clear picture of what he is to do and how much authority he has to get it done.

2. The scope of the job must be defined for him. This is essential to keep him on the right track.

3. He must be acquainted with the people with whom he has to deal.

4. The importance of the job must be specified.

5. He must be coached a little and prepared psychologically for new responsibilities.

6. The manager must at all times retain control of the operation. It must be remembered that when he delegates, he never really gets rid of the final responsibility.

7. Management must be sure to follow up. It is not wise to wait until the job that has been delegated is complete, because errors could be too expensive and too hard to correct.

There are a number of good reasons why management should delegate work and let subordinates share the load. A few of the basic reasons are:

1. Delegation produces better answers to specific problems.

2. Delegation promotes better understanding in the organization.

3. When subordinates assist in formulating decisions, they are better able to accept and understand management decisions and the reasons for them.

4. Subordinate participation develops a sense of loyalty to the organization.

5. Delegation develops a succession of management and administrative personnel.

6. Delegation eases the load on the manager.

Although he cannot recall the source, the author once read and noted something quite pertinent to the problem of delegating responsibility: "In a modern industrial society the fundamental antagonism is not between those who own capital and those who do not, important though that distinction may be, but is between those who take re-

sponsibility and manage and discipline, and those who are given no responsibility and are managed and disciplined, and no solution of industrial problems is possible unless that antagonism is removed."

Managerial Pitfalls

Sometimes men learn best by their mistakes. Certainly, in the field of management, there have been many failures. Extensive and exhaustive study indicates many managers have failed because:

1. They listened only for what they wanted to hear.
2. They failed to create a genuinely permissive atmosphere in which the subordinate felt free to express himself frankly and completely.
3. They did not recognize that their real strength rests not in themselves but in the people they manage.
4. They permitted distractions, petty irritations, and prejudices to divert them from the main track in the discussion of business problems with their associates and subordinates.
5. They did not recognize the need for getting an employee's complete participation.
6. They paid only lip service to the principle of two-way communication.

Correction of these faults is an important step toward creating successful executive management.

Use of Aerial Photography for Preparation of Distribution System Maps

William S. Staub and Cramer G. Bollinger

A paper presented on Mar. 25, 1960, at the West Virginia Section Meeting, Huntington, W.Va., by William S. Staub, Partner, Kelley, Gidley & Staub, Cons. Engrs., Charleston, W.Va., and Cramer G. Bollinger, Partner & Gen. Mgr., W. E. Bollinger & Sons, Commercial Photographers, Charleston, W.Va.

IN a study of water projects for small communities, one of the first obstacles generally encountered is the lack of an adequate map showing facilities in the community. Inadequate maps also impede studies involving the distribution system of an existing water property. If a map is available, it is usually old, incorrect, and does not show corporate changes, changes of streets, or additions to property. In most instances, updating an existing map is a very time-consuming and costly process; furthermore, the map may contain basic errors. It has been found that a very satisfactory method for preparing project maps is by utilizing techniques of aerial photography. This method has been used in several recent projects, and, as it has proved satisfactory, further use of the method should be made.

In many parts of the United States, much use has been made of aerial photography for making maps pertaining to utility work, but the method should be brought to the attention of those who are now operating a water system with inadequate maps. The method may be adopted for mapping an existing system or for designing a new one. The preparation of the base map and tracings is the same in both instances. For an existing system, however, lines, valves, and hydrants are located by measurement and pipe-locating equipment and placed on the maps to scale.

Aerial photography played a very important role during World War II. Since then many companies have been organized to render this type of photographic service. In preliminary studies of many interstate highways, turnpikes, and toll roads, the utilization of aerial mapping has greatly expedited the work at a reasonable cost. Thus, a procedure found to be workable and economical in providing maps for a distribution system should be of interest to those concerned with water supply.

Preliminary Study

When the need for a map exists, the first step is to investigate the area to be mapped and, by field inspection, set the boundaries. The use of topographical sheets—1:24,000 or 1:62,500—is useful in this preliminary work. The boundaries may be sketched to scale on these sheets to serve as a guide during further negotiations with the photographer.

At this point, it is advisable to determine the scale of the preliminary

and final plans and usually desirable to have a general map of the entire system. This map may vary in scale according to the size of the system and should provide a layout of the entire project to serve as a key map for the construction drawings. The scale of the general map should range from 1 in. = 200 ft to 1 in. = 600 ft.

with the photographer, estimates may be obtained of alternate scales of completed photographs. Such estimates will not affect the costs materially or delay the initial phases of the project.

Flight Data

The photographer should be advised well in advance of the requirements of

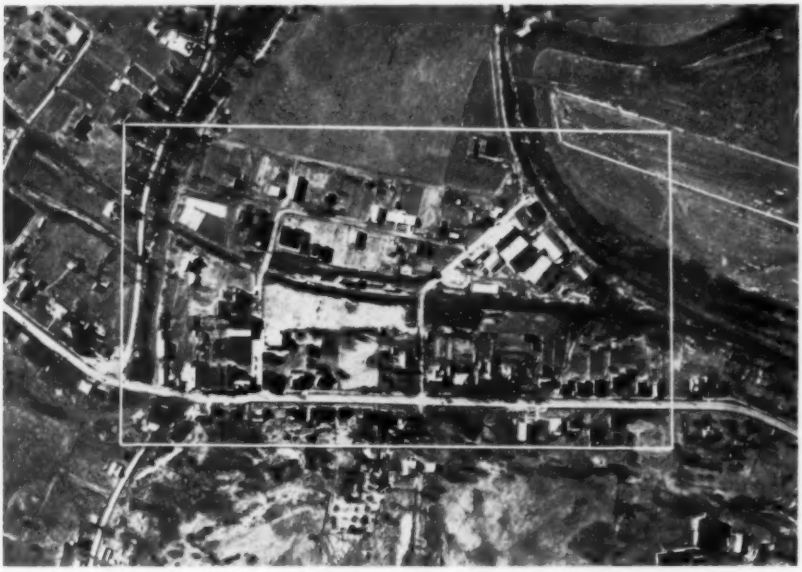

Fig. 1. Aerial Photograph of Distribution System Site

The scale of the photograph is 1 in. = 400 ft. The print served as the basis for the preparation of a detailed map, with a scale of 1 in. = 50 ft, of the area outlined.

The final maps will also vary in scale according to the size of the system. A scale of 1 in. = 50 ft is satisfactory for water distribution drawings and will permit sufficient detail for most systems. Further enlargement of street intersections or other areas may be made if additional detail is required. For purposes of negotiations

the engineers, in order that he may take advantage of the best weather. The US Weather Bureau and the Bureau of Standards have determined from studies made in previous years that approximately 60 days per year of cloud- and haze-free skies—conditions needed for good vertical photography—are available. Best results

are obtained by the use of a lens with a 10-in. focal length, which would require the aircraft to fly at an altitude of 4,000 ft to produce a print with a scale of 1 in. = 400 ft (Fig. 1). A lens with an 8.25-in. focal length, at an altitude of 3,300 ft, produces the same scale.

The sky should be clear of clouds and haze, and the wind velocity should be not more than 15 mph. Bad weather makes for greater error in the flight strip, which should overlap at least 55 per cent on each subsequent negative and appear in a straight line, with not more than 3 per cent drift from the center line of flight.

For purposes of discussion, it may be assumed that the engineer has decided on a scale of 1 in. = 400 ft. The photographer completes his flight at the required elevation, and, after the negative is processed, he makes 9×9-in. contact prints for the engineer to take in the field and establish control point locations from which actual measurements are made. In this way, accurate control points are set up for the ratio enlargements, which would be 8 to 1 to produce the scale of 1 in. = 50 ft in the final prints.

Ground Control

The 9×9-in. prints of the aerial photographs, at a scale of 1 in. = 400 ft, are satisfactory for use in ground control. These prints, however, may correspond in scale to the scale of the general map, thus eliminating the need for extra prints. Each of the prints must be examined to fix points that can be readily identified on the ground and on the print. The points chosen should generally be along a tangent of a road or street. It is advisable that the view between points be unobstructed and that they be preferably 800–1,000 ft apart. The selected points may be centers of road intersections or center lines of paved driveways, walkways, or projected building lines. Ground control involves the determination of the horizontal distance between two such points. The distance between points may be measured by "chaining" or by the use of the stadia survey method.

Actual ground distances are marked on the map, and the points are designated on the print. A sketch on the reverse side of the map is helpful to the photographer for checking the actual ground points used, because a pencil point may cover several feet on the print, causing the photographer to have difficulty in interpreting exact locations. This control is important, because all future enlargements are based on these marked distances for true scale.

Enlargements

It is a good idea to indicate on the prints any areas that will not require future enlargement, such as open fields and hilly areas, in order to permit a savings in cost. Enlargements are priced per square foot.

After the small prints are returned to the photographer, with the designated control points and actual distances marked, the enlargements are produced to true scale. These enlargements are prepared on sheets of photographic paper that are usually 40 in. wide and 48 in. or 60 in. long, whichever can be handled more practically. Adequate overlap between sheets is provided in order to match enlargements.

Tracings

When the final enlargements are received, the draftsman starts the layout work with the use of 24×36-in.

tracing-film sheets. This film, because of its transparency, is ideal for photo tracing. With the film, the amount of tracing work a draftsman can complete in a day has more than doubled. The tracings show paved roads, sidewalks, fence lines, streams, bridges, and buildings, and constitute the basic map.

On a recent project, pipe was located along a state route for a distance of 8 mi. Engineers were able to obtain prints from the state road commission having the same scale as the available maps. By matching, it was possible to show on the tracings the right-of-way lines of the road. It was also possible to indicate culverts and drainage structures. The tracings made from the aerial photographs matched the road maps very closely and thus provided another good check on the accuracy of the work.

Field Checking

When a print of the basic map is ready to be field checked, such items as culverts, drains, manholes, sewers, water and gas lines, or any other underground obstructions are marked on the prints. This information can be furnished by utilities, city employees, and by inspection. At the same time, the field location is chosen for mains, and measurements from curb lines and paved surfaces are made so that this information may be placed on the map. Also, service lines are located, and such pertinent data as types of buildings, business places, and apartments are recorded. When this information is plotted and designated on the tracing, along with match marks and titles, the sheet is ready for a final field check to verify its accuracy and to check for any omissions.

Progress in Revision of the Positive-Displacement Meter Standard

Committee Report

A report of Committee 8610 D—Meters, submitted by James G. Carns (chairman), Meter Engr., American Water Works Service Co., Philadelphia, Pa. Other members of the committee are R. R. Anderson, H. F. Barrett, W. B. Cambridge, P. R. Carlon, M. B. Cunningham, F. G. Hundley, J. E. Johnston, A. P. Kuranz, W. E. MacDonald, H. W. Niemeyer, J. F. O'Grady, G. C. Sopp, and H. Wilkins Jr.

AFTER almost 2 years of consideration, the AWWA Meter Committee has not yet completed the work of revising the present AWWA standard [1] for positive-displacement meters. At its meeting on May 16, 1960, the committee discussed several minor and one or two major items which will need further consideration. None of the items at issue are such as to postpone a final vote unduly, and it is anticipated that the revised standard will be submitted to the Water Works Practice Committee and the Board of Directors for final approval before the end of 1960.

Basic Difficulty

The committee's difficulty has been in preparing a practical standard applicable to meters best suited for the myriad types of water encountered throughout the country. Obviously, such a standard should require that meters be as accurate as commercially possible; that they be constructed of materials that will assure long life; that they be of standard sizes and dimensions; that they have such other desirable features as low friction losses and low maintenance costs. Furthermore, the manufacturer must be able to provide all of these characteristics at a reasonable cost. To specify all this in one standard is, to say the least, not a simple matter. Although the committee feels that the present version of C700 is excellent in many respects—and the present form of presentation is, for that reason, being maintained—it is believed that certain proposed changes will prove to be beneficial.

Materials

The most important change proposed is that having to do with materials used in fabricating basic component parts. The present standard is open to very broad interpretation in this respect. It is axiomatic that specifications must be restrictive if protection is to be afforded the purchaser. If they are unduly restrictive, however, an adverse result may occur. Unfortunately, none of the arts of chemistry, metallurgy, or manufacture has been developed to the point where one set of basic materials can be economically utilized to produce meters that are completely satisfactory for universal use. Therefore, a new section, setting

forth permissible materials of which the major component parts may be made, is being incorporated in the standard. This establishes a "floor" or minimum for such materials, and the choice of materials to be incorporated in the standard is based on past experience and the most informed professional judgment. The committee is satisfied that the materials selected provide for the manufacture of a standard product best suited to the majority of installations. As an example of this change, the present standard provides only that measuring chambers shall be made of bronze or a nonferrous composition. In the proposed revision, however, measuring chambers furnished for standard meters are to be made of a copper alloy containing a minimum of 85 per cent copper, with suitable percentages of tin, lead, and zinc.

The quality of water meters produced in the United States is now the highest it has ever been, and the committee feels that the manufacturers are to be commended. The permissible materials and limits specified in the new standard are designed to insure that this high quality can be maintained as well as to provide the added protection that materials other than those that have been proved satisfactory cannot be utilized. Obviously, such tightening of the standard requires that there be some provision to permit the use of whatever improved materials may be developed. This is handled by a provision that amendments of the material requirements may be proposed by one or more of the meter manufacturers, and that the Meter Committee must render a decision, based on majority vote of its members, within 1 year from the date of application for the revision.

Registers

One great problem, which is the result of the lack of prior standardization, is the diversity of meter registers, particularly those of round-reading type. In the 1920's, this phase of the standard was reviewed by the Meter Committee, but it was not resolved, because of the reluctance of many users to accept a register of a different type from those already in service. Unfortunately, in the intervening years the situation has become no better, and it seems almost impossible now to select a standardized round-reading type register that would be universally accepted. The committee is convinced, however, that this situation cannot continue indefinitely, and it is, therefore, proposing a start toward standardization of this feature. The proposal is that any new model of meter, as distinguished from modifications of existing models, first offered for sale after the issuance date of the revised standard, is to be furnished with an "AWWA Standard straight-reading register." Improvements in the design and reliability of straight-reading registers since the early models, plus the recent introduction of sealed registers, should tend to overcome the reluctance of many who previously would not accept this type of register. The number of errors in reading meters in recent years directly traceable to the use of meters with several different types of round-reading registers has reached a stage where steps to replace this difficulty are necessary, as there is no indication that the situation will improve otherwise.

Several other changes have been made owing to the recent development of sealed registers. Also, the use of

open gear trains is being removed from the standard. The dimensions of meters and connections have been placed in tabular form for clarity. The notes appended to the standard have also been changed in several respects, again for the purpose of clarity and brevity, and the AWWA Standard for Testing Water Meters (C705) has been incorporated in the notes.

Meter Accuracy

The committee believes the accuracy requirements of the present standard to be sufficiently stringent to provide meters capable of accurate measurement for sustained periods. It is noted, for example, that ⅝-in. meters are presently being produced with accuracies higher than 95 per cent on the minimum flow test of ¼ gpm, which under certain conditions produces a slight overall improvement in meter registration. At the same time, however, meters with the close tolerances required to produce this slight improvement are more subject to operational difficulties. The committee therefore concluded that any further tightening of accuracy requirements would not be justified by the overall results produced. Even the present accuracy requirements must be modified somewhat when meters are to be used in areas where high water temperatures are encountered. The larger clearances between the piston and measuring chamber, which are required to avoid meter stoppage through expansion under such conditions, make it necessary to accept a flow accuracy below the requirements of the present standard. Any increase in the accuracy requirements of the standard would thus only enlarge the area of deviation from the standard in such cases.

Friction Losses

The meter friction losses permissible under the present standard have been criticized as unduly high by some individuals. The committee is aware, of course, that several meters presently being produced have losses lower than the standard permits, which would seem to indicate the permissible losses could and should be reduced to some extent. Meter friction loss is, of course, important. It is, however, only one of several factors involved in adequacy of service to a customer. The collective experience of the committee indicates that meter losses do not present a problem in the overwhelming majority of installations and are not such as to warrant establishment of lower permissible losses. In those instances where friction loss is a critical problem, other factors, such as main pressure or service line and house piping losses, constitute the major problems, which a reduction in meter friction losses alone could not overcome. Conversely, if the major deficiencies are corrected, meter loss becomes relatively unimportant. The whole question involves a judgment factor, and the committee does not believe that major redesign or completely new designs of meters are warranted. Even if it were possible to effect lower meter friction loss by new design, higher meter costs might well be involved.

Piston Speeds

No changes in piston speeds have been proposed, as piston speed is interrelated with friction loss. In the pres-

ent standard, manufacturers are given a range within which to work to develop the best possible product, at a reasonable cost. The committee believes the manufacturers should have this working range.

Conclusion

It is hoped that the final results of the revision of C700 will be made available for further review in the very near future. The committee sincerely hopes that its efforts will be justified in an improved standard for positive-displacement meters.

Reference

1. AWWA Standard for Cold-Water Meters—Displacement Type—AWWA C700. Am. Wtr. Wks. Assn., New York (1946).

Reprints Available

Reprints of the following articles, published in the JOURNAL during recent months, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 2 Park Avenue, New York 16, N.Y. A handling charge of $1 will be added on all orders under $5 unless accompanied by payment in US or Canadian funds or in AWWA Publication Discount Coupons.

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R1011	EDITORIAL STATEMENT	Style Manual for Journal Authors	May 60	16	25¢

Use of High-Tensile Steels

Joint Discussion

A joint discussion presented on May 18, 1960, at the Annual Conference, Bal Harbour, Fla.

High-Pressure Transmission Lines—*H. Arthur Price*

A paper presented by H. Arthur Price, Sr. Project Design Engr., Dept. of Water & Power, Los Angeles, Calif., and Chairman, Committee 8310 D—Steel Pipe.

ENGINEERS in the water industry are using high-tensile steel more and more in high-pressure steel transmission lines. The impetus has come from the oil and gas industries, which, in the last decade, have used thousands of miles of high-tensile steel pipe. These industries purchase pipe under American Petroleum Institute (API) specifications 5LX, and use three grades of steel: X42, X46, and X52. Grade X42 steel has a yield point of 42,000 psi; Grade X46, a yield point of 46,000 psi; and Grade X52, a yield point of 52,000 psi.

Design Factors and Economy

With regard to design factors, in the oil and gas industries pipe is designed to have a working stress of 40–72 per cent of the yield point strength, depending on the location of the pipeline. For example, for use across deserts and remote areas, pipe is designed to have a stress as much as 72 per cent of the yield strength.

There are certain advantages in using Grade X42 steel for water lines. The pipe, however, should not be designed to have a working stress more than 50 per cent of the yield strength. The use of high-tensile steel is advantageous because steel plate can be used economically. Grade X42 steel has a premium of 0.5 cent a pound over ASTM Grade C steel, which is used to a great extent in the water supply field. If, for example, Grade X42 steel were used, the pipe could be designed to have a stress of 50 per cent of the yield point, or 21,000 psi. If ASTM 283 Grade C steel were used (yield point, 30,000 psi), and if the pipe were designed to have a stress of 50 per cent of the yield point, or 15,000 psi, the savings would then be in the proportion of 15,000 to 21,000. When the small premium of 0.5 cent per pound for the plate is considered, the saving is approximately 25 per cent of the cost of the plate itself. What does this mean as far as dollars saved on a project? The Los Angeles Department of Water and Power installed a 48-in. line approximately 7 mi long. The savings in steel plate alone was $132,000. The East Bay Municipal Utility District (EBMUD) of Oakland, Calif., is installing its third barrel of the Mokelumne Aqueduct, consisting of 34 mi

of 88-in. steel pipe; the savings in plate is approximately $500,000.

Fabricated Plate Pipe

Throughout the western United States, various water companies have been buying reject API mill gas pipe, preparing the ends, and installing it in their systems successfully. Buying plate of the same quality as the mill gas pipe plate and fabricating it into pipe according to AWWA standards is very practical and has been successfully done with diameters as large as 60 in. by the Los Angeles Department of Water and Power. The Los Angeles department has found that the plate is weldable and that the type of welding rod that has been used on milder steel plates can easily be used with mill gas pipe plate.

Effect of Stress on Coatings

Manganese is the alloy used in Grade X42 steel plate to give it its high-tensile strength. The specified maximum manganese content is 1.15; the specified carbon content is 0.29. Mill test reports indicate that the carbon content will be less than 0.25; the average manganese content is 1.05.

If high-tensile steel pipe is used, savings usually become evident when pipeline pressures become fairly high and where the external forces are not too great. The designer should not only investigate the internal factors, but also should seriously consider the external loads on the pipe. Grade X42 plate designed to a 21,000-psi stress will have slightly more stretch than will mild steel plate. There is some question about the effect of this stretch on protective coatings. No difficulty could be experienced with coal-tar enamels, inasmuch as the coating is slightly flexible and elastic. As to cement-mortar linings and cement-mortar coatings, EBMUD tested a section of 48-in. pipe that was fabricated with Grade X42 plate and lined and coated with cement mortar. In stressing the pipe to 15,000 psi, common for mild steel plate, very small hairline cracks appeared in both the lining and coating. When the stress was increased to 21,000 psi, no difference was noticed. At 30,000 psi, a slightly greater opening of the cracks appeared, but no additional cracks developed. When the pipe was carried to failure at 80,000 psi, the coatings exploded.

Conclusion

The use of high-tensile steels for high-pressure steel transmission lines has proved practical and economical. It goes without saying that the designer should, in considering the use of high-tensile steel plate, investigate the internal and external forces and apply the correct protective coating for the particular soil environment, just as he would with any other type of pipe material.

Welded Elevated Steel Tanks and Standpipes

James O. Jackson

A paper presented by James O. Jackson, Pres., Engineering Development Co., Coraopolis, Pa., and Chairman, Committee 8710 J—Joint Com. on Steel Standpipes and Elevated Tanks.

Joint Committee 8710 J—Steel Standpipes and Elevated Tanks, of AWWA, NEWWA, and AWS has considered, on several occasions in the past, the use of alloy or high-tensile steels for the construction of welded elevated tanks and standpipes. After a thorough evaluation of the advantages and disadvantages, it has been concluded that no particular advantage results from the use of high-tensile steels in tanks, except for the reduced volume of weld metal required to make joints between thick plates. Further, there are believed to be disadvantages from the use of high-tensile steel which need to be carefully evaluated.

Cost Factors

The mill price of alloy or high-tensile steel plate is disproportionately higher than the price of low-carbon steel plate, with regard to strength. The thicker steel resulting from the use of low-carbon steel is of advantage in tank structures because of its increased corrosion allowance. For plates 1–2 in. thick and greater, the volume of required weld metal in the joints becomes important, and the corrosion allowance becomes less important. In this thickness range, therefore, it is desirable to reduce the plate thickness and, consequently, the amount of welding, because the volume of weld metals varies approximately as the square of the plate thickness. With high-tensile steels, however, the saving in volume of weld metal is usually largely offset by the increased cost or difficulty of making welds in high-tensile steels. This increased cost results from required preheating and the use of higher-cost filler metal.

Unit Stress

The present AWWA standard for steel tanks and standpipes (D100) specifies a unit stress in tension of 15,000 psi and a joint efficiency of 85 per cent for butt-welded joints. The maximum thickness permitted to be welded is specified as 2 in. Under these restrictions, the height of a standpipe, in feet, multiplied by its diameter, in feet, may not exceed 9,800. A standpipe 100 ft high may not have a diameter greater than 98 ft or a capacity greater than 5.65 mil gal. A standpipe 50 ft high may have a diameter as large as 196 ft and a capacity of up to 11.3 mil gal. A standpipe only 10 ft high may have a theoretical diameter as large as 980 ft, with a total capacity of 56.5 mil gal. In all these instances, the maximum thickness of the bottom ring will be 2 in. When AWWA unit stresses and joint efficiency are applied to a standpipe 200 ft in diameter, the stretch in the first ring, when the tank is filled, will amount to approximately 3.3 in. in circumference, or 1.05 in. in diameter. It is known from experience that the lower edge of the first ring does not stretch as much as the

foregoing figures indicate, because of the restraint of the flat-bottom plates. This interaction between the bottom plates and the lower part of the first-ring shell is an important consideration in the use of high-tensile steels, for the stretch of these steels will be increased directly in proportion to the increased working stress, which will aggravate the degree of restraint between the bottom and the first-ring shell plates. For example, with regard to a 200-ft diameter standpipe, if the first-ring shell plates stretched under tension to assume the full bursting stress of the water load, there would be set up a force of approximately 3,190 lb/lin. in. of circumference between the flat-bottom and the first-ring shell plate. This force is approximately equal to the water load on shell plates 150 in. high. Actually, the bottom plates are not stretched to this degree, and measurements in the field on large standpipes have shown that the stretch in the bottom is only a fraction of this amount. The effect of this restraint is to subject the welds between the shell and the bottom plates, and the welds in the bottom plates themselves, to increased forces and to bending moments. These forces and bending moments result from the eccentricities of the welds and from the fact that bottom plates are often fillet welded from only one side. Therefore, if higher stresses are used in the shell plates, more care should be given to the design of the welds in the tank bottom and between the shell and bottom. The welds in the tank bottom might better be made butt welds without edge preparation and without the necessity of 100 per cent penetration, and welded from the top side only.

No standpipe failures are known to have resulted from the restraint between the shell and bottom. It must therefore be assumed that past practice has been conservative. It seems obvious, however, that if, for example, the shell stress were increased, through the use of high-tensile materials, to twice its present value, or 25,500 psi, the diametral stretch would be 2.10 in., which would be cause for considerable concern.

Because the joint between the bottom and the first-ring shell is subjected to considerable restraint and to appreciable plastic deformation, it is important that highly ductile, tough steel be used, so that it will deform and adjust its configuration to the distortion resulting from the restraint. If it is considered essential to reduce the thickness to save on volume of weld metal used, it seems more advantageous to use an arbitrarily established higher working stress for a metal with good ductility and toughness than to use a higher unit stress for a metal that has poorer ductility and that may be more brittle at the minimum working temperatures. For this reason, where thicknesses have been reduced in the past, such material as A201 ASTM Grade B flange quality steel, with an ultimate strength of 70,000–82,000 psi and an elongation in 8 in. of 19 per cent, has been successfully used. A212 high-tensile carbon-silicon steel has been used; when it is flange quality Grade B, with an ultimate strength of 70,000–82,000 psi, it has a ductility of 18 per cent, but requires preheating and special electrodes in welding. A131 structural steel for ships, with an ultimate strength of 60,000–72,000 psi and an elongation in 8 in. of 18 per cent, is a very suitable steel for use when the

first rings are subjected to restraint, because of its excellent ductility, welding properties, and toughness at low temperature.

The use of high-tensile steels in elevated tanks has not been considered worthwhile, because plate thicknesses are generally less than 1 in., and the additional corrosion allowance that results from the use of ordinary steel is more significant than the savings in weight of material and in welding.

Conclusion

The use of high-tensile steel in elevated tanks and standpipes is generally undesirable, but, with flat-bottom tanks, where it is necessary to reduce the thickness of the first ring to meet code requirements or to realize savings in welding costs, materials of greater strength may be used, provided that there is no sacrifice in ductility, toughness at minimum working temperatures, or weldability. Furthermore, provisions should be made for the effects of increased restraint by better welds in the tank bottom and between the first ring and the bottom plates. Tank structures subjected to fluctuating water levels will cause the restrained joint to have more load cycles, and, as the maximum stresses due to plastic deformation are already at the yield point, a shorter tank life may result.

Apparatus for Corrosion Tests With Hot Municipal Waters

Rex M. Guest

A contribution to the Journal by Rex M. Guest, Research Chemist, Dept. of Chemistry, Ontario Research Foundation, Toronto, Ont.

DURING the course of a long-term corrosion investigation, it was necessary to design an apparatus capable of testing specimens under conditions as closely related as possible to those of actual service in a closed system. Speller [1] demonstrated that the rate of corrosion in a closed system increases steadily with an increase in temperature, but in a system open to the atmosphere, a maximum rate is reached at approximately 80°C. It is believed that the test presented is a rigorous one and makes use of the only apparatus of this type that has been fully described.

Apparatus

The test apparatus is shown in Fig. 1. The tank for holding the specimens was 4 ft long, 16 in. in diameter, and constructed of stainless steel. The top was so bolted on that it could be removed readily to expose the entire interior of the tank. A ring with slots for holding eleven rods was attached to the inside of the tank at the top. The rods for holding the samples were of stainless steel and were covered with nylon tubing at first and with plastic * tubing later. The samples were separated with washers made by drilling holes in sections of nylon and plastic rods. Under the experimental conditions employed, the plastic proved to be the only material satisfactory for covering the sample rods and for separating the specimens.

The tank was heated at the top and bottom by heaters connected in the so-called "flip-flop arrangement," which functions as follows: When the top of the tank reaches the desired temperature, the upper thermostat shuts off the top heater and turns on the bottom heater. When the bottom of the tank reaches the operating temperature, the lower thermostat shuts off the bottom heater. Thus, the water around the specimens is always kept at the desired operating temperature.

In order to simulate conditions of intermittent flow in a closed system, the apparatus was equipped with timers and a solenoid valve that allowed water to be drained off at predetermined intervals. By means of one timer,† the solenoid could be opened for a sufficient length of time to drain off varying amounts of water every 2 hr or less. Another timer § was used to shut off the first timer

* Teflon, made by E. I. du Pont de Nemours & Co., Wilmington, Del.

† Flexopulse timer, made by Eagle Signal Co., Moline, Ill.

§ Paragon timer, made by Paragon Electric Co., Two Rivers, Wis.

and thus inactivate the system so that no water was drained off for periods of several hours, if this was desired.

Operating Conditions

The unit was operated at 95°C, and 5 gal of water was drawn off every 2 hr for a period of 16 hr each day. No water was drawn off for the remaining 8 hr. Studies were made with two municipal waters, analyses of which are shown in Table 1. The water pressure at Location 1 was 60–80 psi; at Location 2, 40 psi.

The different steel samples for the unit were selected and positioned with the use of a system of random numbers. Duplicate samples were removed for examination at periods of 1, 2, 4, and 8 months, and so on in the progression until the end of the test period. The samples were cleaned with dilute, inhibited hydrochloric acid.*

TABLE 1

Analysis of Municipal Waters

Constituents	Location 1	Location 2
	Concentration—*ppm**	
pH	7.12	8.6
Dissolved oxygen	8	8
Free carbon dioxide	45	—†
Total alkalinity	288	24.0
Phenolphthalein alkalinity	—†	2.0
Dissolved solids	380	82.8
Total hardness	320	65.5
Iron	0.3	0.04
Silica	22.6	4.5
Calcium	73.2	22.5
Magnesium	27.3	2.0
Sulfate	14.3	22.8
Chloride	10.2	3.8
Free chlorine	0.1	0.075

* Except for pH.
† No concentration recorded.

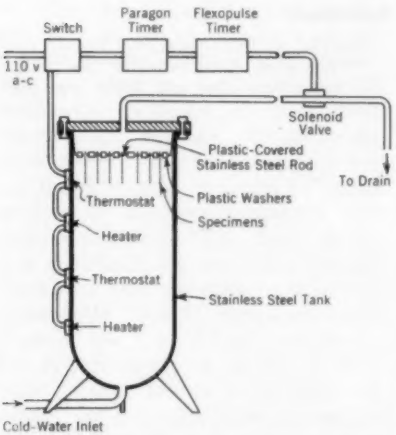

Fig. 1. Apparatus for Corrosion Test

The stainless steel tank was 4 ft long and 16 in. wide. The top of the tank was so bolted on that it could be removed to expose the interior of the tank.

Results

Exact numerical results regarding weight losses or the actual pit depth curves for each water will not be given here, but it is hoped that a general discussion of the results will suffice to demonstrate the value of the apparatus. Although the maximum pit depth was approximately the same regardless of which municipal water was employed, the number of pits in the softer water at Location 2 was many times greater than the number of pits in the harder water at Location 1. Also, the area of the pits formed in the softer water was much smaller

* The inhibitor was Rondine-60, a product of American Chemical Paint Co., Ambler, Pa.

than the area of the pits formed in the harder water.

The change of maximum pit depth with time could, in general, be represented by the curve shown in Fig. 2. In the figure, maximum pit depth refers to the depth of the deepest pit found on the two samples removed at a particular time, and not to the rate of penetration of a single pit on a single sample. It will be noted that the rate of pitting slows up with time, but does not completely level off. Some samples were investigated over periods as long as 20 months. In many instances, it was found that some of the pits had completely penetrated samples $\frac{1}{8}$ in. thick during the 8- and 16-month periods.

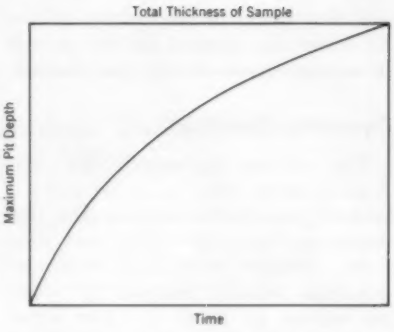

Fig. 2. Typical Curve for Change of Maximum Pit Depth With Time

Maximum pit depth refers to the depth of the deepest pit found on two samples removed at a particular time.

Summary

The apparatus described has proved satisfactory in testing the corrosion of steel specimens in a closed system using municipal waters. The results of tests carried out over a period of several months have proved that the composition of the corrosion medium, and not the composition of the steel samples, is the important factor.

Reference

1. SPELLER, F. N. *Corrosion, Causes and Prevention.* McGraw-Hill Book Co., New York (3rd ed., 1951). p. 168.

Submersible Water Well Pumps

Claud R. Erickson

A paper presented on May 15, 1960, at the Annual Conference, Bal Harbour, Fla., by Claud R. Erickson, Mech. Engr., Board of Water and Elec. Light Comrs., Lansing, Mich.

PRACTICALLY all large metropolitan areas obtain their water supply from lakes, rivers, or reservoirs, but most smaller towns and a good number of larger cities pump their water from deep wells. The search for additional water in areas served by deep wells has led to deeper and deeper wells and pump settings.

With the conventional line shaft deep well pump, line shafts have had to be extended greater lengths, which, in turn, has brought about higher power losses due to turbulence around the pump shaft and to bearing friction. The long shaft has also multiplied the mechanical problems of maintaining the shaft and bearings. Primarily for these reasons, many communities are for the first time showing an active interest in submersible pumps and their application. The most important considerations, normally, are the fixed cost and operating cost of the submersible pump compared with those of line shaft pumps and the effect of various setting depths on these costs. Other factors to consider, of course, are reliability, ease of maintenance, and, if the well is located in a residential area, quietness of operation.

The characteristics of the line shaft pump are generally familiar to those concerned with obtaining water from deep wells, whereas there may be many who are not well acquainted with the submersible pump. For this reason, part of this article describes, in some detail, the various types of submersible pump motors on the market, and touches briefly on some of the basic precautions that should be taken in the installation and testing of these units.

Lansing System

The Lansing (Mich.) Board of Water and Light, which serves a population of approximately 130,000, obtains all its water from 106 deep wells. Of these, 64 wells are equipped with line shaft pumps, six are equipped with submersible pumps, and the remaining are air lift wells usually used only during heavy demand periods. The submersible pumps have only been in service since 1952; as a result, unfortunately, meaningful maintenance cost comparisons are not available.

A typical well in the Lansing system is 420 ft deep and consists of a 14-in. casing 80 ft long driven down until firmly anchored in bedrock. The remaining depth is mainly through sandstone and shale and the bore is 13¼ in. in diameter.

The deep well pumps installed recently have an average setting depth of 300 ft and the static water level is approximately 100 ft below grade. The specific capacity averages 6.3 gpm/ft.

History of Submersible Motors

Submersible motors for driving pumps are not a recent development. The first patent on this type of motor was taken out in 1908. The motor was of the wet-stator type, and no attempt was made to protect the windings from water. This design required a heavy, waterproof insulation on individual conductors. Although the operation of this first motor was satisfactory, the unit was bulky for the power it produced, and the demand for this type of unit was slight.

Little was done to develop this motor further until the late 1920's, when several new patents were issued. Since that time, submersible motors have gained wide acceptance, and today there are three basic types: the dry stator, the wet stator, and the oil-filled stator.

Wet-Stator Type

In the wet-stator motor, water is free to circulate throughout the motor and provide proper cooling in addition to lubricating the shaft and thrust bearings. This requires that all individual conductors be insulated with a waterproof material. Rubber insulation was used in the first motors, but it is now general practice to use a plastic insulation such as polyethylene. All parts in contact with the water, except the rotor and stator laminations, are normally made of noncorrosive materials. Carbon steel must be used for the rotor and stator laminations, as corrosion-resistant materials do not have the necessary magnetic properties.

Some manufacturers treat the laminations so as to combat the corrosive effect of the water, and most manufacturers recommend filling the motor with clean water and depending on a seal to keep the interchange of water to a minimum. This type of motor has proved very successful, and corrosion does not appear to be a serious problem. This can probably be attributed to the fact that once the small amount of oxygen in the water has been dissipated through the formation of corrosion products, there is no way for the oxygen to be replenished except from the small interchange of water which may take place.

This type of motor is generally of larger physical size than the other types for similar horsepower ratings, because waterproof material protecting the windings is much thicker than the wire enamel used in an oil-filled or dry-stator motor. An advantage of this motor is that it is of simpler construction and possibly more foolproof than the other types.

Dry-Stator Type

In the dry-stator motor, a thin, nonmagnetic metal tube surrounds the rotor and seals it off from the stator. The rotor bearings are submerged in a coolant-lubricant of water, a water-oil mixture, or a water-grease emulsion. If the coolant is water, it is sometimes, but not always, sealed in the motor, depending on the design. The metal tube is swept by magnetic lines of force and is therefore inductively heated. This, of course, represents a small power loss, and the resultant temperature rise has been known to cause the metal tube to collapse. Some manufacturers of this type of motor have tried to overcome this difficulty by lining the tube with a polyester filler having a high thermal conductivity. Standard varnished windings are generally used in this type of motor, but a recent development used by at least one manufac-

turer consists of filling the hermetically sealed stator case with a solid plastic material to anchor the windings against vibration and to assist in the dissipation of heat. Dry-stator motors, in general, have proved very successful.

Oil-Filled Stator

The oil-filled-stator motor is widely used in the United States, especially in the larger sizes. The complete unit is filled with a high-dielectric-constant oil, which permits the use of standard electrical windings. The oil protects the internal parts from corrosion and allows the manufacturers to use less expensive carbon steel and cast-iron parts. An advantage claimed by some manufacturers is that any well equipped motor repair shop can service this type of motor, because special windings are not used.

A very important component of the oil-filled-stator motor, of course, is the seal between the shaft and the motor housing at the top of the unit. This seal must be so designed as to reduce the loss of oil to a very small amount and prohibit the entrance of contaminating water, which would cause motor failure. Either a mercury or a mechanical seal is used for this purpose.

The mercury seal does an effective job of retaining the oil in the motor and excluding the water with no shaft wear, but it has two limitations: the motor must be operated in a vertical position, and mercury is expensive.

A mechanical seal is used on most of the smaller motors and on many of the large ones. With this seal there is a slight oil loss along the shaft and a larger oil supply is therefore provided, sometimes in the form of a spring-loaded reservoir at the base of the motor. The manufacturers claim that with the slight loss permitted, the supply of oil is sufficient for many years of operation.

Advantages of Submersible Pumps

The submersible pump can be installed in holes that might be too crooked for a line shaft pump. Because there is no alignment problem caused by a long drive shaft, operation is smooth and quiet. As long as there is sufficient room to install the pump, such a well can be readily used.

When wells are located in residential neighborhoods the noise from a large pump motor located aboveground can be very disturbing to those living within a radius of several hundred feet of the well house. On the other hand, even a large submersible pump can operate deep in a well without noise. Before submersible pumps were used in the Lansing system, it was sometimes necessary to substitute an expensive low-speed pump and motor for the normal 1,750-rpm unit in order to reduce the noise to an acceptable level.

The search for an adequate and dependable water supply sometimes leads to the development of wells on or near a river bank in areas which are subject to frequent flooding. In such a location, expensive precautions must be taken to protect the well and vertical line shaft motor from damage by flood waters. On the conventional pump, passage of the rotating shaft through a stuffing box offers a route by which contamination may enter. With the submersible pump, there is no danger of motor damage from water and the problem of surface water contamination of the well is completely eliminated through the use of a watertight seal at the top of the casing and a watertight seal where the submersible power cable enters the well.

It should be pointed out that even though the top of the well is tightly sealed against contamination some state health laws require that an automatic sump pump be installed in the pit.

Protection against weather or vandalism is not needed. This often results in a substantial saving, especially when the well is located in a residential area and an appropriately designed well house would otherwise be required. A submersible pump also offers increased protection to personnel.

A submersible pump can be installed and removed more rapidly and economically than a line shaft pump, as there is no line shaft to assemble or disassemble. This is especially important when the wells have to be dynamited at frequent intervals.

If smaller-capacity units are used, submersible pumps are often more economical to operate, because the line shaft loss with the conventional pumps becomes greater than the sum of the cable loss and the difference in efficiency between the submersible and standard motors.

Disadvantages of Submersible Pumps

The efficiency of the submersible motor is less than that of the standard motor, owing primarily to the resistance offered by the coolant within the motor. Submersible motors are also more expensive than standard motors.

The repair of a submersible motor usually requires sending it back to the factory, whereas a standard motor can normally be repaired in a local shop. Also, submersible pumps must be removed to adjust clearances for wear, whereas adjustments of a line shaft pump can be made from the top of the motor. Most manufacturers do not recommend submersible pumps where sand is likely to be encountered.

Reduced-Voltage Starters

The starting current of a submersible pump motor is considerably less than that of a standard deep well motor of the same rating. The reason for this is that there is less inertia in the rotating parts, because the rotor diameter is much less and only a short pump drive shaft is required.

For motor sizes of 50–200 hp, the standard deep well pump motor requires six times the normal running current for starting, whereas the submersible motor usually draws about four times the normal running current. It is, therefore, often unnecessary to use a reduced-voltage starter with a submersible pump in situations where it would be required with a standard line shaft pump of the same size.

It is important to investigate the maximum starting current allowed by the power company, because the use of reduced-voltage starting where it is not needed can result in damage to the motor. The reason for this is that a reduction in voltage greatly reduces starting torque, which, in turn, further reduces the already low starting current of a submersible motor, resulting in insufficient starting torque to rotate the unit. The use of the low-voltage tap, therefore, does nothing more than overheat the winding and shorten insulation life.

Installation and On-Site Tests

It is very important that certain basic precautions be observed during the installation of a submersible pump. Many manufacturers recommend a step-by-step installation procedure beginning with a check of the incoming electric supply for correct voltage and

wiring in the starter panel before any attempt is made to install the unit. Also the unit should be checked to see if it is free to rotate. In the higher-power machines the power should be momentarily applied prior to mounting of the pump end; in the smaller sizes, the power should be applied just prior to lowering. The direction of rotation should also be observed and corrected if necessary. Care should be taken, of course, to secure the unit to prevent the possibility of its falling from its supports.

The cable splice must be carefully made to insure a watertight connection. Several methods are used and approved and apparently give satisfactory results if properly applied. Experience in the Lansing system has indicated that best results are obtained with a cast splice. This is formed by placing a mold around the connected wires and pouring a prepared resin material, which subsequently hardens, into the mold.

An electrical-resistance test of the cable and motor should be made prior to installing, and checks should be continued as the pump is lowered into the water. A satisfactory reading is 50 megohms or higher, but the motor may be operated with safety down to a value of 5 megohms.

Every submersible pump should be fitted with a control valve in order that the flow of water can be gradually increased as the unit is "run in." This eliminates overpumping of the well and the possibility of sandy water. The control valve also enables an initial check to be made of hydraulic and electrical performance. Pressure, voltage, and amperage readings should be taken at shutoff conditions and permanently recorded. This information will serve as a check against performance guarantees and is a particular point of reference that can be reproduced at any time simply by closing the control valve. This information, in conjunction with resistance readings, will prove invaluable in making a quick diagnosis of the hydraulic, electrical, or mechanical condition of the unit. It is also important, of course, to take test data under various flow conditions.

Submersible-Pump Failures

The majority of causes of submersible pump failures apply equally well to line shaft pumps. Some of these causes are:

1. Overpumping of the well, resulting in the pumping of large quantities of sand or other abrasive particles; partial or complete seizure of the shaft owing to overheating of the bearings or wedging of particles of suspended solid matter; collapse of the well; or breaking of suction and the drawing in alternately of water and air, which applies a severe intermittent load to the motor and could upset the seal or cause a shaft coupling to shear.

2. Natural causes, such as lightning strikes, chemically aggressive waters, or abrasive solids in the water being pumped.

3. Electrical-supply faults, such as voltage fluctuations, single phasing, or "hunting" due to unsatisfactory control gear, which causes the unit to start and stop too frequently.

4. Man-made faults such as short-circuiting of the overload trip with a piece of wire, holding the start and reset buttons in at the same time, or the use of oversize fuses.

Fortunately, these potential failures can be readily guarded against by having full knowledge of the well and making proper checks and tests of the

installation before it is actually put in service.

Operating Checks

Although the submersible pump cannot actually be observed in operation, the careful operator can often tell whether the pump is functioning properly from surface observation. Some of the danger signals that should be noted are:

Line current. A marked increase in line current without a corresponding increase in pumpage indicates a need for immediate attention, particularly if the current is fluctuating.

Resistance readings. It is good practice to check the insulation resistance of the motor and cable at regular intervals (at least once every 6 months) with a 500-ohm meter. A substantial lowering of insulation resistance should be followed by more frequent checks.

Noise. An increase in mechanical noise (as distinguished from hydraulic noise) usually indicates bearing wear either in the motor thrust bearing or in the pump bearings.

Costs

All costs shown and used in the calculations and tables that follow are user's costs and are based on current (1960) prices quoted by major pump and motor manufacturers with freight allowed to destination. There is, of course, some variation in prices between manufacturers, and the results should therefore be viewed accordingly. Savings can often be effected by purchasing such items as cable and column piping locally. This is especially true of submersible pumps, because random lengths of pipe are used. All power costs are based on a charge of 1½ cents per kilowatt-hour.

TABLE 1

Selection of Most Economical 350-ft Cable by Comparison to Heaviest Cable*

Item	Cable Size							
	No. 2	No. 1	1/0	2/0	3/0	4/0	250 MCM	300 MCM
	Amount—$							
Saving in annual fixed charges	155.50	141.10	130.00	125.90	110.20	92.10	42.30	21.0
Added annual power cost								
4,000 hr operation	100.30	73.40	74.60	37.60	26.40	15.70	9.40	4.50
6,000 hr operation	150.40	110.10	81.90	56.40	39.60	23.50	14.10	6.70
8,000 hr operation	200.60	146.90	109.20	75.20	52.80	31.30	18.80	9.00
Economic advantage over heaviest cable								
4,000 hr operation	55.20	67.70	55.40	88.30†	83.80	76.40	32.90	16.50
6,000 hr operation	5.10	31.00	48.10	69.50	70.60†	68.60	28.20	14.30
8,000 hr operation	−45.10	−5.80	20.80	50.70	57.40	60.80†	23.50	12.00

* For use with 75-hp, 44-v motor; full-load current 101 amp.
† Most economical selection.

Power Cable Selection

Extreme care should be exercised in deciding on the proper cable sizes for a given installation. The minimum

cable size for a given permissible voltage drop or I^2R loss is rarely the most economical size. Factors which influence cable sizes are the cable cost, power cost, hours of operation per year, depreciation period, and, of course, ampere loading and setting depth.

Table 1 shows the method used in selecting the most economical cable for a given motor size. The annual fixed charges were taken as 11.5 per cent of the cable cost and include depreciation at 7.5 per cent, interest at 3.5 per cent, and insurance at 0.5 per cent. The table is based on a 300-ft setting depth (350-ft cable length) and shows with a full load rating of 101 amp, the manufacturer's recommendation would have been a No. 2 cable.

The use of three-conductor cable was assumed for motors up to and including 100 hp; for larger motors the use of single-conductor cable was assumed. The reason for this is that the larger sizes of three-conductor cable are difficult to handle, require more space between the column and casing, and cost approximately 20 per cent more than single-conductor cable. Some manufacturers suggest using two three-conductor cables for the larger motors. If single-conductor cables are used, it is necessary to clamp the cables

TABLE 2

Manufacturers and Types of Submersible Motors

Manufacturer	Type	Coolant & Lubricant	Max. Horsepower
Byron-Jackson Pumps, Inc.	oil filled, open winding	oil	750
Fairbanks, Morse & Co.	wet stator	water	250
Reda Pump Co.	oil filled, open winding	oil	500
General Electric Co.	oil filled, open winding	oil	150
Lancaster Pump & Mfg. Co.	wet stator	water	550
US Electrical Motors, Inc.	dry stator	water and glycol	300
Westinghouse Electric Corp.	wet stator	water	250

the proper cable for 4,000, 6,000 and 8,000 hr of operation per year.

From Table 1 it can be seen that the most economical cable sizes are 2/0 based on 4,000 hr of operation per year, 3/0 based on 6,000 hr, and 4/0 if 8,000 hr of operation is anticipated. The length of cable does not determine the most economical sizing, but must be considered in determining the minimum permissible size.

It was found that the most economical size was, in most cases, several sizes larger than that recommended by the pump manufacturer. In the given example, which is for a 75-hp motor securely close together to the side of the column at short intervals to prevent spreading and resultant losses through inductive reactance.

Power Supply Voltage

The study includes pumps requiring motor sizes up to 300 hp. Not all the manufacturers listed (Table 2) can supply submersible motors of this size. The larger motors (100 hp or more) are designed for 440 v or 2,300 v, depending on the manufacturer's standards or customer's preference. The data in this article are based on 440-v motors only, as this voltage is

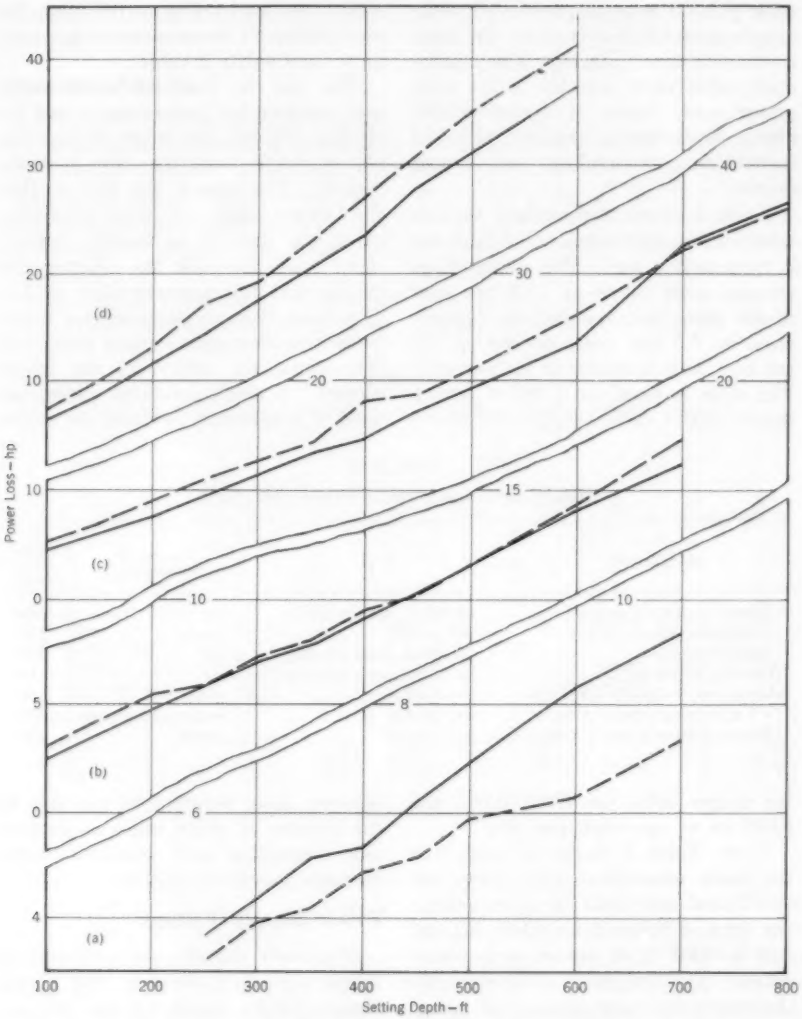

Fig. 1. Comparison of Total Power Losses in Line Shaft and Submersible Pumps at Various Setting Depths

Solid and dashed curves represent data for line shaft and submersible pumps, respectively. Part a, *6-in. column and 200-gpm pumping rate; Part* b, *8-in. column, 500-gpm pumping rate; Part* c, *10-in. column, 1,000-gpm pumping rate; Part* d, *10-in. column, 1,500-gpm pumping rate.*

nearly always available and 2,300 v is not as readily obtainable. The cost of 2,300-v motors is usually slightly more than that of 440-v motors, but a considerable saving can be effected in the cable loss or cable cost if 2,300-v current is available.

Motor Manufacturers

Table 2 lists the principal types of large submersible motors for deep well service. Table 3 shows the outside diameter of several makes at various horsepower ratings.

Comparison of Power Losses

From the power loss curves in Fig. 1, it will be noted that when pumping at 200 gpm the submersible unit has a considerably lower total loss at all pump setting depths, whereas at 1,500 gpm the line shaft pump has a definite advantage. At the intermediate capacities of 500 gpm and 1,000 gpm, the advantage of either pump is less distinct, but the data appear to favor the line shaft unit.

The reason for this trend is that at the lower capacities the shaft friction loss is a much higher percentage of the total horsepower requirements than at the higher capacities. At 200 gpm, this loss constitutes nearly 10 per cent of the total brake horsepower, whereas at 1,500 gpm this loss amounts to less than 3 per cent. The most efficient submersible motors were used in all calculations.

TABLE 3

*Outside Diameters of Several Submersible Four-Pole Motors**

Manufacturer	20 hp	25 hp	30 hp	40 hp	50 hp	60 hp	75 hp	100 hp	125 hp	150 hp	200 hp	250 hp	300 hp
	Outside Diameter—*in.*												
US Electric Motors	9¼	9¼	9¼	9¼	9¼	9¼	9¼	9¼	13½	13½	13½	13½	13½
General Electric Co.	10 7/8	10 7/8	10 7/8	10 7/8	10 7/8	10 7/8	10 7/8	10 7/8	10 7/8	10 7/8			
Westinghouse Electric			9¼	9¼	9¼	9¼	9¼	10¼	10¼	10¼			
Byron-Jackson Pumps	8	8	8	10	10	10	10	10	14	14	14	14	17
Fairbanks, Morse			10	10	10	10	12	12	12	14	14	14	

* Most of the manufacturers also make two-pole motors, but usually in only the smaller sizes, although some go up to 40 hp and higher.

Motor Efficiency

There is a wide variation in the efficiencies claimed by the various manufacturers of submersible motors. Even the most efficient submersible motors, however, are considerably less efficient than comparable surface motors. It is its greater efficiency which makes it possible for the line shaft pump to compete on an economic basis with the submersible pump. Often the difference is more than enough to offset the shaft friction losses and higher column losses of the line shaft pump. In Table 3 the full-load efficiencies of a number of submersible motors are compared with those of a typical line shaft motor.

The thrust loss for both the line shaft and submersible pumps has been disregarded in all calculations, because the amount is insignificant for the type of motors under consideration. This loss, however, can be appreciable with some other types of submersible motors.

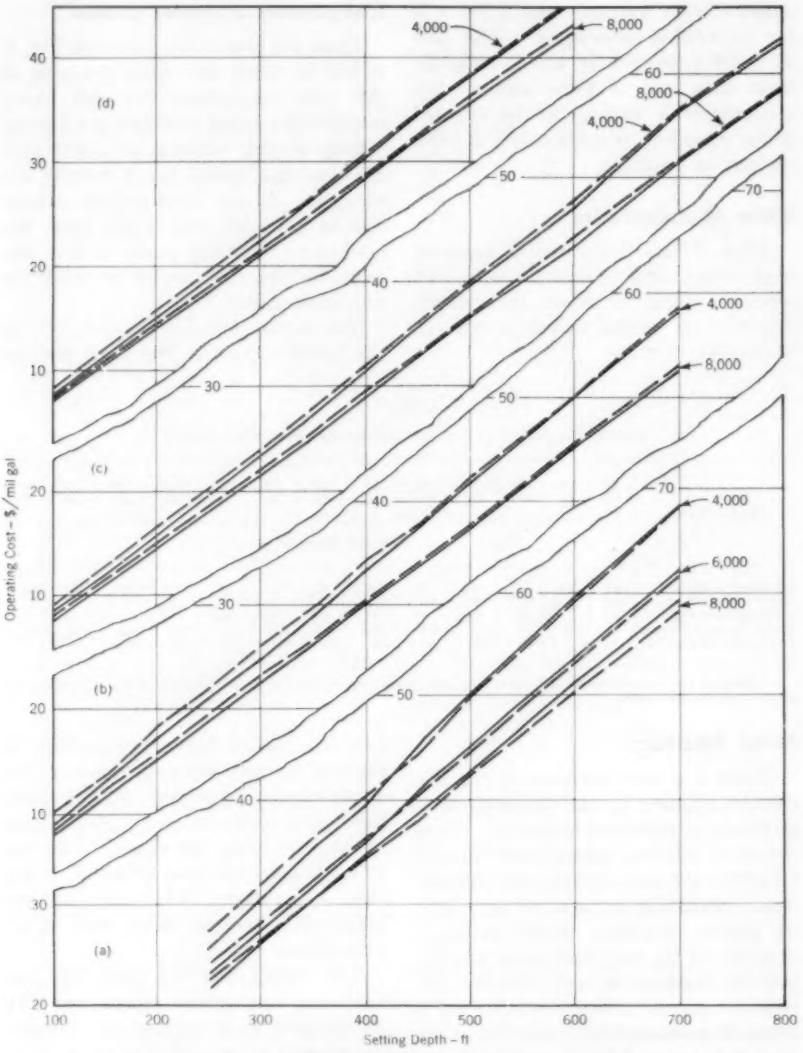

Fig. 2. Comparison of Production Costs With Line Shaft and Submersible Pumps at Various Production Rates and Setting Depths

Solid and dashed curves represent line shaft and submersible pumps, respectively. Each pair of curves is labeled to show the number of hours of operation per year. Parts a, b, c, *and* d *represent data for pumping rates of 200, 500, 1,000 and 1,500 gpm, respectively.*

Comparison of Pumpage Costs

Figure 2, showing the cost per million gallons of water pumped, indicates that at a capacity of 200 gpm, pumping costs are lower with a submersible pump (based on at least 4,000 hr of operation per year). At the higher capacities the line shaft pumps appear to have a very slight advantage at most setting depths. It should be noted, however, that the costs do not reflect the fixed charges on a well house or maintenance costs. These costs were not included, because the cost of a well house can vary from several hundred to several thousand dollars, and, as already stated, maintenance costs on submersible pumps were not available.

Comparison of Capital Costs

A comparison of capital costs is shown in Fig. 3. As would be expected, the submersible motors are considerably more expensive than the line shaft motors, although with deeper settings, the total cost of the submersible units approaches that of the line shaft units. This is especially true of the larger-capacity units, and it should be noted that in the 1,500-gpm size the submersible unit is less expensive at settings deeper than 450 ft. The cost of the complete unit given in Fig. 3 includes such items as the motor adapter and surface plate for the submersible pump and the pump head and suction piping for the line shaft unit. This additional equipment is not included in the breakdown prices.

Proper Setting Depth

Setting a pump at the proper depth is important if the most economical operation is to be obtained. Unfortunately, this problem often receives too little attention, and, as a result, pumping costs are higher than necessary.

Figure 4 indicates a method of selecting the right setting depth. Although conditions naturally vary from system to system, the basic method should be generally applicable. The figure is based on the assumptions that:

1. The well is drilled 100 ft deeper than the setting depth.
2. A 14-in. well is used with motors up to and including 100 hp, a 16-in. well up to and including 250 hp, and an 18-in. well with a 300-hp motor.
3. The static water level is 100 ft below grade level.
4. The well is cased to a depth of 80 ft.
5. Reduced-voltage starters are used on motors of 100 hp or more.
6. Fixed costs are 11.5 per cent of total capital costs, including labor and material for a complete well and pump

TABLE 4

Full-Load Efficiencies of Various Pump Motors

Motor Horsepower	Submersible Motors			Line Shaft Pump Motor
	A	B	C	
	Full-Load Efficiency—*per cent*			
20	83.0	84.0		89.0
25	86.0	85.5	81.0	89.5
30	86.0	86.5	81.5	91.0
40	86.0	87.5	83.5	90.5
50	86.0	88.0	84.0	91.0
60	88.0	88.5	84.0	91.5
75	88.0	89.0	84.5	92.0
100	88.5	89.5	85.0	92.0
125	87.0	89.5	84.2	92.5
150	86.0	89.5	85.5	92.5
200	87.0		87.5	92.5
350	89.0		87.5	92.5
300	89.0			92.5

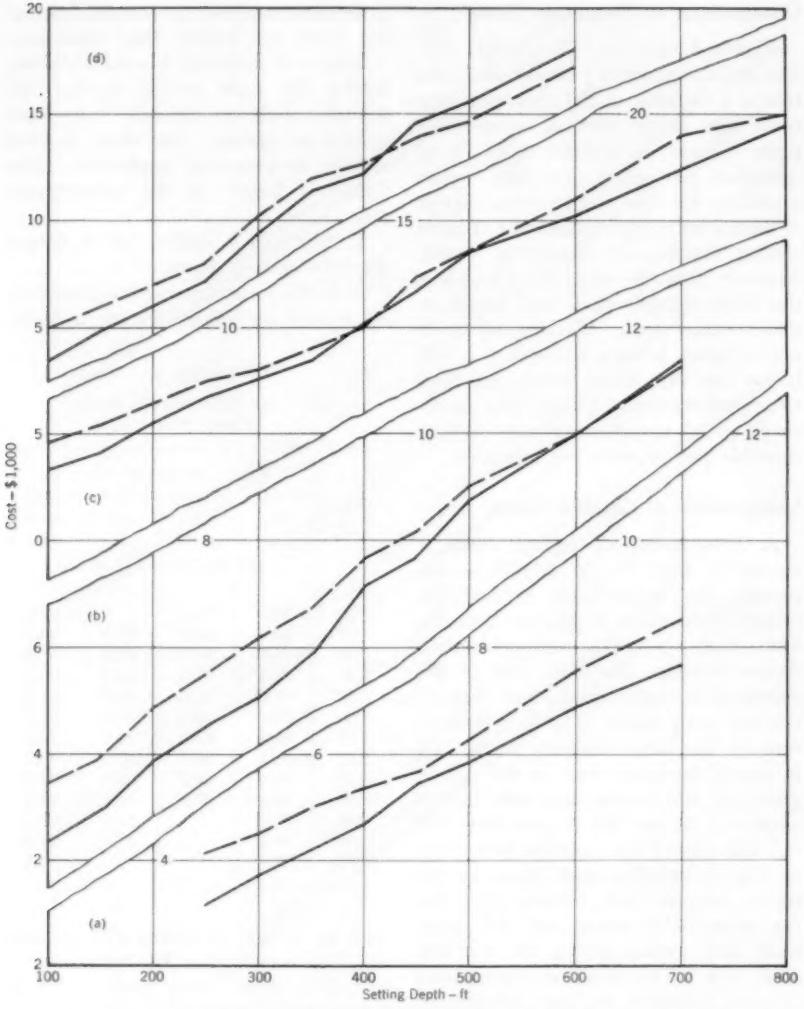

Fig. 3. Comparison of Costs of Line Shaft and Submersible Pumps for Various Setting Depths

Solid and dashed curves represent data for line shaft and submersible pumps, respectively. Parts a, b, c, *and* d *are for pumping rates of 200, 500, 1,000, and 1,500 gpm, respectively.*

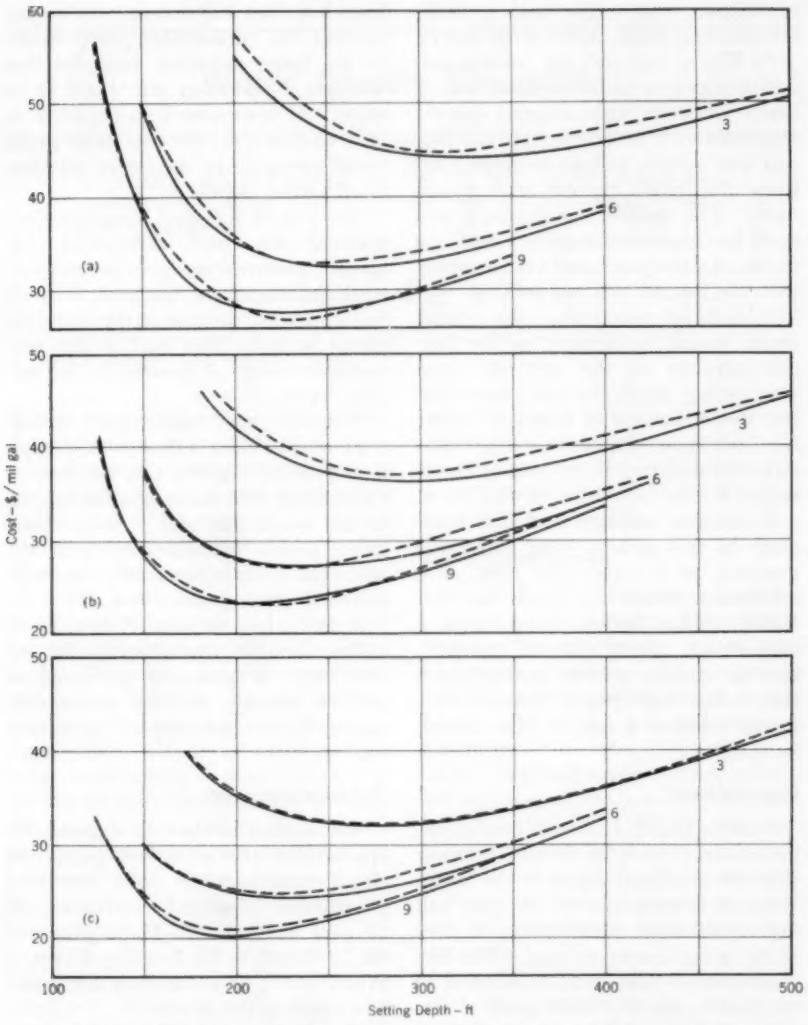

Fig. 4. Most Economical Setting Depths for Line Shaft and Submersible Pumps

Solid and dashed curves represent data for line shaft and submersible pumps, respectively. Parts a, b, *and* c *give data for 4,000, 6,000, and 8,000 hr of operation per year, respectively. Each pair of curves is labeled to show the specific capacity (in gallons per minute per foot of drawdown) of the well considered.*

installation, real estate, and a 14-in. transmission main, 1,000 ft in length.

In Fig. 4, the cost per million gallons pumped is plotted against setting depth for wells with assumed specific capacities of 3, 6, and 9 gpm/ft. The cost per million gallons is determined from the fixed charges and power costs. The specific capacity of a well must be determined experimentally by means of a test pump and varies greatly with the type of well and locality.

It will be noted that the setting depth should be reduced as the specific capacity of the well increases. The setting depth becomes somewhat less as the number of hours of operation per year increases. The most economical setting is, of course, represented by the low point on the curve.

If records indicate that the water table in the area is being gradually lowered, as is often the case, then allowances should be made for this factor. Other factors being equal, a submersible pump should possibly have a slightly greater setting depth than a line shaft pump to avoid cavitation, because a suction pipe cannot be used.

Conclusions

From a purely economic standpoint, maintenance excepted, it would appear that the line shaft pump is the better selection in capacities of 500 gpm and higher, although the advantage is very slight at the deeper settings. The line shaft pump is also more economical in the lower capacities (200 gpm) at settings less than 400 ft deep. At deeper settings the submersible pump would be the better selection, provided that the annual operation was 4,000 hr or more. If operation was expected to be less than this, the line shaft pump would probably be the better selection at all setting depths.

The cost of standard manufacturer's material was used throughout. If special construction, such as stainless-steel shafting, were specified, it could easily increase the cost of the line shaft pump to more than that of the submersible pump at practically all setting depths.

Although no maintenance figures were available for submersible pumps, it is generally agreed that the cost of maintaining line shafts goes up rapidly as the length increases. At least one large pump manufacturer will not quote prices on a line shaft pump with a setting depth greater than 350 ft.

It can safely be stated that there is a place for both types of pump; the line shaft unit is generally preferred at shallow settings, and the submersible makes its best showing at the deeper settings.

Acknowledgment

The author wishes to express his appreciation to the various pump and motor manufacturers who furnished information presented in this article, as well as to E. P. Darlington and M. L. Beard, of the Lansing Board of Water and Light, for their assistance in compiling the data.

Water Quality Standards

A Symposium

A group of papers presented on May 17, 1960, at the Annual Conference, Bal Harbour, Fla., on the value, use and development of water quality standards.

Introduction—*Ray L. Derby*

A paper presented by Ray L. Derby, Prin. San. Engr., Dept. of Water & Power, Los Angeles, Calif.

IN order to judge the quality of any product, it is necessary to have some standard. Ask the old-timers in the country, many of whom claim that their water is the best in the United States or even in the world, why they think so, and they usually reply that "it tastes good, looks good, does not smell, and nobody dies." These four criteria of potability are, of course, basic. Nowadays, however, communities are growing in size and number, and have become more and more industrialized. Natural water sources have consequently become more vulnerable to pollution from domestic and industrial wastes. Many of the newer polluting substances are such that the senses of taste, sight, and smell are no longer a help in determining the potability of water.

All too often in the recent past man has been confronted with illness of some sort before he realized the dangerous character of his water supply. Sixty years ago, the incidence of typhoid fever in major United States cities drawing their water from surface sources was a national disgrace. Since that time, however, standards and criteria have been developed and have played a major role in the detection and control of pollution, until at the present time very few cities have records of recent serious illness traceable to their water supplies.

USPHS Standards

In 1914, USPHS, then operating under the US Treasury Department, developed standards for water used on interstate carriers.[1] These common carriers now include railroads, buses, planes, and steamships, and most of the major cities serve one or more of them. For uniformity within individual states, a majority of the 50 states have adopted the USPHS standards as a requirement for a permit to supply domestic water within the state itself. A few states have no definite standard, and the remainder have their own standards.

The USPHS standards aimed at what was thought to be the major danger in water supplies. The standards had three major kinds of requirements: (1) bacteriologic; (2) physical; (3) chemical.

The bacteriologic standard specified a maximum coliform organism content and a maximum total bacterial

content. The physical standard placed limits on such things as the taste, odor, and turbidity of a supply. The chemical standard limited the concentration of certain chemicals that were known or thought to be detrimental, such as arsenic, iron, zinc, and copper.

Revisions of Standard

There have been many changes in the USPHS Drinking Water Standards, the latest being made in 1946.[2] In addition to the bacteriologic, chemical, and physical standards, the 1946 standard also requires that the water supply come from a source free from pollution, or one in which pollution may be reduced by natural agents or one in which the water may be treated by artificial means.

The bacteriologic requirements have changed in that the total-bacterial-count criterion has been abandoned, as a result of experience indicating that many otherwise satisfactory waters might frequently have a high nonpathogenic bacterial count owing to the presence of organic nutrients in the water.

The physical requirements still closely guard those conditions which are most obvious to the water consumer—taste, odor, and appearance.

The chemical requirement has been modified considerably over the years, and there has been much agitation in the last few years—with considerable justification—for a thorough review of many of the former limits on the content of certain chemical substances. Selenium and nitrates are two substances that have received a great deal of attention in the past few years. The permissible copper content has been increased over its original limit, as has that of zinc. There has also been much agitation in recent years for relaxing the limits on chromium, at first thought to be highly injurious to humans. A number of well qualified biochemists claim that the human body can stand amounts of chromium somewhat higher than those specified in the 1946 standard. There have also been requests for limits to be set for such substances as cadmium, cyanide, ABS, and radioactive materials.

The limit for total solids has been debated for some time. Originally set at 500 ppm, it was relaxed to permit up to 1,000 ppm where there is no other water source available. Although this may be a reasonable requirement where the water is used for interstate carriers, which are generally supplied by large water systems, the adoption of these standards by state departments of health and their uniform application to all water purveyors throughout the state have no doubt caused hardships in some localities. There are many communities where the only source of water available within economic limits is one which frequently may contain as much as 1,500–1,600 ppm total solids. Such supplies have, however, been used for many years without apparent injurious effect. California, at present, is recognizing this situation, and now, rather than denying a permit to use such a supply, is issuing temporary permits with the hope that the community may eventually find other, less mineralized supplies or the means to treat its inferior supply at a reasonable cost.

Sanitary Engineering Practices

In addition to the drinking water standards, USPHS has also made certain recommendations in regard to sanitary engineering practices. This is an important step toward the true evaluation of the potability of a water

supply. These recommendations of sanitary practice permit the exercise of judgment in evaluating the safety of a water supply. As is well known, many water supplies that are normally safe may at times be subject to very serious contamination. On the other hand, other supplies, coming from areas practically free from potential pollution, may have bacteriologic analyses normally inferior to those of the former supplies. The second supply could actually be by far the safer supply.

There is no doubt that during the past 14 years thinking in regard to drinking water quality has undergone considerable change. It is, therefore, quite timely that consideration be given to revising these standards and bringing them up to date. As it has been mentioned, the very fact that the USPHS standards have been adopted for general use by the majority of the states makes it advisable that they be given a thorough evaluation at this time.

References

1. Drinking Water Standards. *Pub. Health Repts.*, 29:2959 (1914).
2. Drinking Water Standards. *Pub. Health Repts.*, 61:371 (1943). Reprint 2697.

New USPHS Standards—*Omar C. Hopkins and Oscar Gullans*

A paper presented by Omar C. Hopkins, Deputy Chief, Water Supply & Pollution Control Div., USPHS, Washington, D.C., and Oscar Gullans, Chief Filtration Engr., South Dist. Filtration Plant, Chicago, Ill.

Although the USPHS Drinking Water Standards were first adopted in 1914 to protect the health of the traveling public, the general and widespread use of the standards has led to their development into a document applicable to water supplies generally throughout the United States. AWWA has thus accepted the standards.

It has been 18 years since the last major technical change was made in the standards and 14 years since an editorial change was made. Atomic energy and other technological developments require their review and updating.

Original Requirements

In reporting on the 1914 standards[1] the USPHS Advisory Commission decided that their problem was to recommend not standards of purity but limits of impurities such as to meet the following requirements:

1. That the water supplies conforming to the prescribed requirements be free from injurious effects on the human body and free from offensiveness to the senses of sight, taste, and smell

2. That supplies of the quality required be obtainable by common carriers without prohibitive cost

3. That the examinations necessary to determine whether a given water supply meets the requirements be as few and as simple as consistent with their purpose.

These basic concepts are still valid.

The 1914 commission recommended only maximum bacteriologic limits because: (1) the control of waterborne disease was the most important con-

sideration facing the commission; (2) an agreement was possible on bacteriologic standards; (3) it was very difficult to assess the health effects of the physical and chemical characteristics of water; and (4) information as to the source and protection of the water supply was not generally available.

Revisions

The commission utilized the knowledge and resources then available to meet the most pressing water quality problems. This same procedure was followed in the first revision of the standard in 1925,[2] when new sections on "source and protection" and "physical and chemical characteristics" were added, and again in 1942 and 1946,[3] when the standard expanded the definition of the water supply system to extend from the water source to the free-flowing outlet of the ultimate consumer. This same philosophy is also guiding the present revision.

A USPHS Advisory Committee for the revision of the 1946 Drinking Water Standards has been appointed by Assistant Surgeon General M. D. Hollis, Chief Sanitary Engineer, USPHS, and has met twice, in March 1959 and in March 1960. This committee is composed of representatives of thirteen national and professional organizations, including AWWA and three federal agencies, and one member at large. A technical subcommittee of USPHS officers was appointed to assist the committee. At the same time, a task force on toxicology was established to review the chemical standard.

Committee Recommendations

In the committee's discussion of the standard it was unanimously concluded:

1. The proposed standard should be discussed widely before a final report is submitted.
2. A new section on radionuclides should be added.
3. Greater attention should be given to the chemical substances being encountered increasingly in both variety and quantity in water sources.
4. The rationale employed in determining the various limits should be included in an appendix.
5. The proposed format, with the exceptions noted above, should not differ greatly from the present standards.
6. The standard document should be suitable for general use.
7. The proposed standard should continue the use of the two types of limits, "recommended or permissive" and "mandatory or maximum," used in previous editions. (Some consideration was given to including a third type of limit, an optimum-level or "incentive" limit, but, with the exception of fluoride, this limit has not been proposed.)

In the current revision, the "mandatory" limit is used to protect the health of water users from toxic substances. The "recommended" limit is used to indicate the levels at which the water is made objectionable to an appreciable number of people. Both limits are included for some substances.

'Source and Protection' Section

It is proposed to rewrite the "source and protection" section approximately as follows:

The water supply shall be: (a) obtained from a source which is adequately protected by natural means or; (b) adequately protected by treatment.

The water supply system should be demonstrated to be free of health hazards by frequent sanitary surveys. The frequency of these surveys and the rate at which discovered health hazards are to be removed shall be established by a program approved by the reporting agency and certifying authority.

Approval of water supplies shall be dependent in part upon the existence of: (a) rules and regulations to prevent the development of health hazards; (b) periodic inspections to evaluate the adequacy of protection of the supply throughout all parts of the system; (c) the operation of the water supply system under the charge of responsible personnel whose qualifications are assured by a recognized authority; (d) a system capacity adequate to meet peak demands without creating low pressures or other health hazards; (e) a record of frequent laboratory examination showing consistent compliance with the water quality requirements of these standards.

For the purpose of application of these standards, responsibility for the conditions in the water supply system shall be considered to be held by: (a) the water purveyor from the source of supply to the connection to the customer's service piping; and (b) the owner of the property served and the municipal, county, or other authority having legal jurisdiction from the point of connection to the customer's service piping to the free flowing outlet of the ultimate consumer.

The statements that the water supply system is to be under the supervision of qualified personnel and adequate to meet peak demands were removed from the section on definitions, where they were frequently overlooked, and inserted in this section where they should receive more adequate consideration. It is also made clear that these statements apply to the entire water system and not just to the treatment works.

Bacteriologic Quality

Practically no change has been made in the section on bacteriologic quality. The membrane filter technique has been designated as an acceptable test for coliform organisms and the minimum number of samples per month for populations under 2,000 has been increased from one to two. An attempt was made to develop a rational method for determining the minimum number of samples required per month. From a purely statistical point of view, this could be done. Knowledge concerning the many factors involved is so inadequate, however, that it was found advisable to defer the attempt. An effort will be made in the near future to secure additional information on the subject in cooperation with the members of AWWA.

The problem of enteric viruses in water is of increasing concern. Techniques of virology have not been adequately developed, however, to recommend virus enumeration as a routine procedure in the examination of drinking water. It was decided to discuss the virus problem only briefly in an appendix.

Physical Characteristics

It is proposed to revise the physical standard to recommend that: (1) turbidity should average less than 5 units; (2) color should average less than 15 units; (3) the threshold odor number should average less than 3; and (4) the water should have no objectionable taste. Under special conditions, the reporting agency and the certifying authority may permit

deviation from these requirements if the water supply meets the other requirements of the standards and if the supply is the best one available.

The requirements on turbidity, color, and odor are generally attainable by properly designed and operated treatment plants and distribution systems. Failure to meet these requirements indicates inadequate facilities, improper operation or an unsuitable raw-water supply. Those water supplies used without treatment should also meet these requirements.

Although these tests do not directly measure the wholesomeness or safety of the water, they are related to consumer acceptance of the water. The average levels of 5 units of turbidity, 15 units of color, and a threshold odor number of 3 are levels above which these characteristics become objectionable to a considerable number of people. Experience has shown that under such circumstances, many people turn to alternative supplies which may be less safe.

Many individuals consider that the usual treatment plant can produce water of potable quality exceeding these requirements and that the limits should therefore be lowered. There is no unanimity on this point, however. Too little is known about the deterioration of the physical quality of water in distribution systems. The standards, of course, refer to the water people drink and not the plant effluent. Again, with the cooperation of the members of AWWA, it is hoped that changes in quality of water as it passes through the distribution system may be studied.

Radiologic Quality

It has been decided that radiologic criteria of drinking water quality will be included in the revised standards. The development of these criteria will depend upon receipt of recommendations from the Federal Radiation Council, which was established on Aug. 14, 1959, by executive order. On Sep. 23 Congress, in Public Law 86-373, made the Federal Radiation Council a statutory body. The council, consisting of the secretary of the Department of Health, Education, and Welfare as chairman, the chairman of the AEC, and the secretaries of Defense, Commerce, and Labor, is directed to advise the President on radiation matters which directly or indirectly affect the national health. This advice is to include guidance for all federal agencies in the formulation of radiation standards.

TABLE 1

Chemical Limits Not Affected by New Revision

Substance	Limit* *ppm*
Chloride (as Cl)	250
Chromium (hexavalent, as Cr)	0.05*
Phenol	0.001
Sulfate	250
Total solids	500

* The limit on chromium is mandatory; all others are recommended.

It may be anticipated that the recommendations made to the President by the Federal Radiation Council and subsequently issued by the President as policy guidance for all federal agencies will consist of broad guidelines rather than detailed operational standards. The individual agencies will be required to prepare operating standards based on and consistent with these policy guidelines, which are expected to be available sometime this year. It should not take too long to develop

acceptable standards, once the guidelines are received. Probably the most difficult task will be to prescribe practicable procedures for insuring the radiological safety of water supplies without requiring an undue amount of radiochemical work.

Chemical Characteristics

The 1914 standards were bacteriologic standards because the main problem facing the water utility operators at that time was the control of waterborne disease caused by living organisms. The profession has learned how to cope with this problem, however; it has learned so well, in fact, that very few changes in the bacteriologic section are being proposed.

Today the new challenge facing the water supply profession is the control and removal of the hazardous nonliving contaminants—the chemicals and isotopes which are being produced in a bewildering array of new compounds. It is to be expected that some of these chemicals, as well as the wastes from their production, enter public water supplies. Unfortunately, very little is known about the extent of the pollution of the nation's water supplies by these new chemicals, which include the many commercial poisons.

In the current revision of the USPHS Drinking Water Standards, by far the greatest amount of effort has gone into the problem of setting limits for chemical contaminants. The toxicological task force, under the chairmanship of Herbert Stokinger, accumulated a great deal of information for the committee to consider. It is proposed that much of this material used by the committee in arriving at conclusions be included in an appendix.

Table 1 lists those substances for which no change is proposed at the present time. In fact, there has been very little discussion of these limits. With the exception of the mandatory limit for hexavalent chromium, the proposed limits are recommended limits. As stated in the 1946 revision, water supplies containing these substances in excess of the limiting concentrations should not be used, if, in the judgment of the certifying authority, more suitable supplies are available.

Proposed Changes

Table 2 lists those substances for which changes in the limiting concentrations have been proposed.

Arsenic. No change is contemplated for the "mandatory" limit for arsenic, but in view of present knowledge concerning both the potential health hazard from the ingestion of inorganic arsenic and its toxicity to fish, a recommended limit of 0.01 ppm is proposed.

Copper. The recommended limit for copper is being reduced from 3.0 ppm to 1.0 ppm primarily because of the taste problem.

Fluoride. A recommended or optimum level and mandatory limit based on average maximum daily temperature ranges (set forth in the appendix to the standard) are being considered. The optimum level is the concentration which produces the maximum health benefits. The mandatory limit is designed to protect the population against severe dental fluorosis. Tentative conclusions relative to limits for fluoride have not been reached by the committee and are included for information purposes only.

Iron. It seems desirable to separate iron and manganese.

Lead. The reduction of the mandatory limit for lead from 0.1 ppm to

0.05 ppm is proposed because: (1) lead is a cumulative poison; (2) daily intake of lead in excess of 0.6 mg may result in the accumulation of lead in the body at rates that increase as the daily dose increases; (3) the amount of lead intake from food sources is probably approaching an irreducible minimum, whereas exposure from other sources, such as the atmosphere, is increasing; and (4) it is believed lead exposure should be reduced wherever possible.

Selenium. The presence of selenium in water has heretofore been a matter of only regional importance. The fact that it is now recognized as being toxic to both man and animals makes it essential that limits be set for all water intended for human consumption. In view of current pathological data, the mandatory limit has been reduced from 0.05 ppm to 0.01 ppm.

Zinc. Inasmuch as zinc does not cause serious effects on health but rather imparts undesirable esthetic effects on water in concentrations approximately 15 ppm and greater, a level of 5 ppm zinc as the metal ion has been recommended. Levels of zinc ion of 15 ppm or greater are considered excessive.

TABLE 2

Proposed Revision of Chemical Limits in 1946 USPHS Drinking Water Standards

Substance	Limiting Concentration—*ppm*			
	Recommended		Mandatory	
	1946	Proposed	1946	Proposed
Arsenic (as As)		0.01	0.05	0.05
Copper (as Cu)	3.0	1.0		
Fluoride (inorganic)		1.0*	1.5	3.0*
Iron (as Fe)	0.3†	0.3		
Lead (as Pb)			0.1	0.05
Manganese (as Mn)	0.3†	0.1		
Magnesium (as Mg)	125	50		
Selenium (as Se)			0.05	0.01
Zinc (as Zn)	15	5		

* Variable, depending on average annual temperature.
† Iron and manganese together.

Magnesium. Three properties of the magnesium ion impose a need to restrict its concentration in potable water; these are salinity, intestinal effects, and hardness. Of these, it appears that hardness is the most limiting. The recommended limit is being reduced from 125 ppm to 50 ppm.

Manganese. A recommended limit of 0.1 ppm is proposed, as domestic complaints apparently arise whenever the level of manganese exceeds 0.15 ppm, regardless of the iron content.

New Substances

Table 3 lists the limiting concentrations of substances which are included in the standard for the first time.

Anionic detergent. Because reports of contamination of drinking water

supplies by detergents are becoming more common, recognition of this contaminant seems necessary. More than 75 per cent of the surfactants in household detergents are of the anionic type, the principal agent of which is alkyl benzene sulfonate (ABS). It is largely for this reason that the degree of detergent contamination is established in the terms of the concentration of ABS as well as because reasonably satisfactory laboratory procedures for its quantitative determination are available.

The recommendation of a limit of 0.5 ppm for ABS is justified on the basis that beyond this level drinking water so contaminated may exhibit undesirable foaming. Such a concentration also indicates that at least 5 per cent of the water is of sewage origin.

Barium. No study appears to have been made of the amounts of barium that may be tolerated in drinking water. A rational basis for a water standard may be derived from the threshold limit in air of 0.5 mg/cu m set by the American Conference of Governmental Industrial Hygienists. By making reasonable assumptions as to the retention of inhaled barium dusts and absorption from the intestine, and by including a safety factor, 1 ppm has been derived as a limit that should constitute a "no effect" level in water. Because of the seriousness of the toxic effects of soluble barium on the heart, blood vessels, and nerves, the limit of 1 ppm barium is mandatory.

Cadmium. So far as is known, cadmium is biologically a nonessential, nonbeneficial element. On the other hand, cadmium is recognized to be an element of high toxic potential. All levels down to and including 0.1 ppm of dietary cadmium in drinking water have shown cadmium accumulation in the soft tissues. A mandatory limit of 0.01 ppm for cadmium is therefore proposed.

Cyanide. The mandatory limit of 0.2 ppm cyanide is desirable for the protection of the health of human populations. The mandatory limit provides a factor of safety of approximately 100 and is set at this level because of the rapidly fatal effect of cyanide and to minimize chlorine demand. Proper chlorination under neutral or alkaline conditions will reduce hydrogen cyanide to the recommended level.

TABLE 3

New Chemical Limits to be Included in Revised USPHS Standards

Substance	Limiting Concentration—ppm	
	Recommended	Mandatory
ABS	0.5	
Barium (as Ba)		1.0
Cadmium (as Cd)		0.01
Cyanide (as HCN)	0.01	0.2
Nitrates (as N)	10	
CSCFE*	0.2	

* Chloroform-soluble carbon filter extract.

Nitrates. High nitrate content in private well waters has been reported to cause methemoglobinemia in infants, but public supplies have not been so involved. Although precise limits have not been established, it is generally agreed that water containing more than 10–20 ppm of nitrate nitrogen should not be used to feed infants. The committee believes, therefore, that a recommended limit of 10 ppm nitrate nitrogen should be established. If the nitrate content of the water exceeds the

recommended limit, the public and particularly the medical profession should be informed.

Chloroform-soluble carbon filter extract. The use of chloroform-soluble carbon filter extract (CSCFE) as a practical measure of water quality and as a safeguard against the intrusion of excessive amounts of potentially toxic material into water has been discussed elsewhere.[4] The procedure is proposed as a technically practical one, which will afford a warning against the presence of otherwise undetected and possibly toxic materials in finished drinking water.

The most desirable condition obtainable is one in which there are no chloroform-soluble residues in the water supply as delivered to the consumer. Chloroform-extractable matter in the treated water clearly represents the presence of man-made or natural pollutants in the raw water which have not been removed in water treatment or material (such as lubricants) inadvertently introduced by the water plant. In view of a general inability to define clearly the chemical and toxicological nature of this material, it is most desirable to limit its presence to the lowest obtainable concentration. Analysis of available data indicates that water supplies containing over 200 ppb of CSCFE represent an exceptional and unwarranted exposure of the water consumer to ill-defined chemicals. It has been recommended that drinking water contain not more than 200 ppb of CSCFE.

The committee believes this procedure may be a most important step in protecting the health of the public against the presence of undetected toxic materials in their drinking water. It is considered to be an advanced contribution to water quality control.

Pesticides. Serious consideration is being given to including limits for two groups of pesticides, the organic phosphates and the chlorinated hydrocarbons. The increasing importance of these commercial poisons as possible contaminants of drinking water is recognized, and there is considerable knowledge concerning their toxicity. What is not known is the concentrations that may have to be accepted in water, and simple tests for their detection have yet to be devised. Without such information it is difficult to assign limits for the concentration of any toxic material in water, for it is generally agreed that such limits should be no higher than necessary. It is hoped this problem will be resolved in the near future.

Alkalinity and pH. Limits on alkalinity and pH are being considered, but no definite conclusions have been reached. Pertinent data bearing on these questions are needed, because it is difficult to define suitable limits.

Conclusion

The status of the revision of the USPHS Drinking Water Standards has been outlined in some detail to provide an opportunity for wide discussion of the standard being proposed. The USPHS Advisory Committee, which is assisting USPHS in this task, will meet at least once more before submitting its report.

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Operator's Viewpoint—*John R. Baylis*

A paper presented by John R. Baylis, Engr. of Water Purification, Dept. of Water & Sewers, Chicago, Ill.

A standard by which to judge the quality of water is a necessity. Fifty years ago there was no standard, except for the efforts of the departments of health of a few states such as Massachusetts. Slow sand filtration was so slow to be adopted by cities in the United States that not much progress has been made in that type of filtration by 1910, 38 years after the construction of the first plant at Poughkeepsie, N.Y., and 81 years after the first slow sand plant in England. The construction of rapid sand filters for public water supplies started in 1885, and by 1910 the number of such plants in the United States greatly exceeded the number of slow sand plants. The rapid growth in the number of new filtration plants and the adoption of chlorination in many unfiltered supplies naturally produced a need for some standard of water quality.

Need for Standard

In 1912, when the author started filtration work the quality of the water furnished to the consumer was largely up to the individual water utility. Some of the public supplies were good, or made good by the treatment plant; others varied from good to dangerous. Each engineer based his design largely on his own idea of the quality that should be produced by the treatment plant. The author recalls a heated argument about chlorination between the late Allen Hazen and other engineers at a water supply meeting. Hazen believed the filter should do all—or nearly all—of the work of treatment, and that a filtration plant should not have to rely on chlorination. In the heat of the argument, Hazen said: "You may kill the bacteria with chlorine, but their carcasses are still in the water."

USPHS Standards

Not many water officials were opposed to the first USPHS standards adopted in 1914. They began to comply with their provisions, especially that relating to the bacteriologic quality. In 1925, there was a change in the coliform-bacteria requirement, making it more rigid. No further major change has been made in the standards. Any quality requirements, such as for bacterial content of the water, must be based on tests made in a uniform or standard method in the various laboratories throughout the country. Standard methods of testing, therefore, are an essential adjunct to standards of quality.

Standard Methods

Standard Methods is an example of a standard that has gone through many revisions to keep up with progress in water treatment. The year 1914 marked the author's first experience in operating a filter after 2 years of supervising the construction of a filtration plant for a city of about 25,000 inhabitants. An important purchase was the second (1913) edition of *Standard Methods*. It was not difficult to learn to perform some of the simple tests such as turbidity, alkalinity, carbon dioxide and soap hardness of the water. The testing procedures given in *Standard Methods* were followed

closely. Effort was made to maintain the bacteriologic requirements of the US Treasury Department for common carriers, with the laboratory of the state department of health conducting the bacteriologic tests. One important early revelation was that the filtered water did not meet the requirements of the USPHS standards without the use of chlorine. This was found to be true for most rapid sand plants. Adding hypochlorite of lime continuously, and in the amounts needed, was not so easy with the chlorine equipment available at the time.

Standard Methods became, and still is, the most important book defining methods of conducting tests in the water laboratory. It should be in all water utility laboratories. All personnel performing laboratory tests, even if only residual-chlorine tests or turbidity tests, should have a copy of the methods readily available. Even though an operator feels he knows the method so well that he could repeat it from memory, he should form the habit of occasionally reading over the procedure. Water treatment technicians should follow every detail given in each test procedure.

The preface to the 1933 edition repeats the prefaces to several earlier editions and gives the names of those who prepared the early methods. The preparation of *Standard Methods* has always been in good hands and has now become the standard manual for water testing.

Originally, *Standard Methods* was published by APHA. AWWA, as an organization, apparently played little or no official part in the preparation of *Standard Methods* until 1923. Since that time, however, the two associations have had an equal share and responsibility in the publication of the standards. The American Chemical Society (ACS), through its section on water, sewage, and sanitation, continued to cooperate in the preparation of the chemical methods. In fact, WPCF (formerly FSIWA), since 1947, has been a partner in the publication of *Standard Methods*.

Standard Methods, as published jointly by AWWA, APHA, and WPCF, is revised from time to time to keep abreast of the times. An excellent job is being done, and has been done in the past, by the committees for preparation of the methods, and this one major tool for determining water quality has been kept up to date for many years.

Turbidity Measurements

The turbidity test is one of the more important tests of water quality. All editions of *Standard Methods* have given methods of preparing standards for making turbidity tests, based on the method used by USGS. For turbidities between 0 and 25, comparison of the water under examination with the standards were made by viewing the water in bottles looking through the side of the bottle. The lowest standard generally was a turbidity of 5. Anyone making a test might use a lower standard or guess at the turbidity between 0 and 5. It soon became the practice of operators to call "zero" any turbidity less than 2 or 3. Operators may have liked this kind of a test because it enabled them to record the water as having zero turbidity, when the actual turbidity may have been 1–2.

Because of the evident urgent need for more accurate turbidity measurement, development of instruments for accurate measurement of low turbidities became essential. The author de-

veloped a floc detector, the Baylis turbidimeter, and the cotton plug filter (for attachment to the effluents of filters). Not much use has been made of the floc detector, although it has proved helpful in some filtration plants troubled with passage of coagulated matter through the filter beds. The Baylis turbidimeter has had considerable use in water laboratories. It is sensitive to a turbidity of 0.05. The cotton plug filter is not being used extensively at present. Its use should increase in filtration plants where there is desire to keep close check on the filters. There are now other turbidity instruments that will measure low turbidities. No filtration plant should be without some sensitive device for measuring the suspended matter that passes through filters, and it should distinguish between colloidal and floc turbidity.

Need for High-Grade Employees

To obtain the most value from the test methods now available, water laboratories must have well trained chemsits and bacteriologists. There has been some recent effort to make water treatment plants so automatic that only a small number of employees is needed. Surely the elimination, or reduction, of the number of technical employees in the plant would be a step in the wrong direction. The present lack of highly educated chemists and bacteriologists in at least some water filtration plants makes one wonder whether an unwise trend in management is being developed.

A certain amount of automation is, of course, helpful in plant operation. Some of the pumping stations are capable of completely automatic operation. The ever changing characteristics of water entering treatment plants requires good technical supervision—supervision that cannot be replaced with automatic devices. Any lessening of such supervision would create a potential health hazard. The author would caution management to go slow in replacing or trying to do without highly trained chemists in water filtration plants.

There seems to have been some lessening of the quality of chemists employed by water utilities. At the same time, there has been an increase in the quality of chemists and bacteriologists employed in public health laboratories. It is true that the modern filtration plant has many mechanical parts to be kept going. Good mechanical equipment alone cannot produce a water of high quality. It cannot decide on the treatment that will produce the best coagulation. It cannot determine how much objectionable industrial waste is in the water, or how much bacterial pollution. Filtration plants in the 10–50-mgd capacity range nowadays usually have one operator who is well trained in keeping the mechanical part of the plant going. He may also do the testing in the laboratory, or there may be a chemist with high school training, or, at most, 1–2 years of college instruction, making pH, turbidity, residual-chlorine, alkalinity, and hardness tests. This may be all the engineer of the plant feels that he needs, but it may not be all that is needed in many water supplies subject to pollution.

When the competent engineer retires, who is going to succeed him? Will it be the none-too-well educated chemist, or another engineer with little or no filtration training? The low salaries now paid chemists and bacteriologists in the water supply field are not going to attract many college

graduates. With equal education, it is just as easy to train the chemist how to operate the mechanical parts of a filtration plant as it is to teach an engineer the chemistry he would need. Standards of water quality that would take the personnel as well as plant facilities into consideration would do much to bring about the selection of better educated chemists in water treatment. This is an important need that is being overlooked.

Need for Research

There is now an urgent appeal for more research in individual water utilities. The need is considered so great that there is even consideration of centralized research with highly trained personnel directing the work. The present situation is largely one of the industry's own creation. Management is too ready to look at the laboratory when a reduction in operating expenses seems essential. The establishment of conditions that would have attracted highly educated personnel to the water supply field in years past would have done much to keep research abreast of changing conditions. There is nothing wrong with centralized research, particularly for certain complicated problems, provided that it does not create the impression that water systems have no need to do further research on their own. There should be an immediate start in the middle-sized and large water systems to employ men who are capable of carrying on the research needed in the particular water system.

Water quality standards that would take the quality of supervising personnel into consideration would do more than anything else to inspire the maintenance of good operating forces in water systems.

Grading System for Utilities

A grading system for water supplies as a whole and for individual filtration plants would do much to promote efficiency. There are several systems that might be used. One will be mentioned, others may be just as good or even better.

A system of letters for four main grades, such as A, B, C and D, is suggested. Grade D would be below the USPHS Drinking Water Standards for water used on common carriers. The other three grades would be approved. The grades should be subject to minus figures. A plant with Grade A water, and no minus figures, would be the perfect plant, both in design and operation, with a source of water that could be handled easily by the plant.

Another plant might have Grade A-10 water. This would mean that some features of design were not the best, or that the operating force was not as well trained or as highly educated as it should be. The deductions could run from figures of -0.1 to about -20, or more, depending on the type and kind of deficiencies. Each deficiency, of course, would not have the same weight. One deficiency might have a weight of -5.0; another might have a weight of -0.2. Under such a system, the author believes the departments of health of the various states, in conjunction with USPHS, should do the grading.

The grades should not be made public; they should be disclosed only to the management of each water utility. Probably some of the departments of health are already using some similar system, even if no record is made. Surely most of them have records giving major deficiencies in the various plants. Small plants, with little or no

chemical control under the direction of a trained chemist, should not be placed in Grade A.

Employee-Training Courses

The departments of health of many or most of the states now conduct water plant employee training courses, or they sponsor courses given by colleges and universities. The operators are given chemical and bacteriologic training in the essential tests for operation, and, no doubt, operation in the small one-man plants has improved as a result.

The person in charge of a moderate-size or large filtration plant should be both a chemist and an engineer, or there should be both a good engineer and a good chemist in the plant. In the proposed grading system, if the operator's knowledge of mechanics is good but his knowledge of chemistry is poor, there would be deductions from the grade. If the plant were classed as Grade B-8 because of personnel deficiency and a few other deficiencies, the grade could be improved by correcting as many of the deficiencies as practical, both in equipment and in personnel.

Promotion and Salary

All filtration plants should have capable employees in the lineup for promotion. Since 1917, the author has worked in only two filtration plants. When he left Baltimore, Md., a chemist with a Ph.D. degree succeeded him, after 8 years of laboratory work. At Chicago, a chemist by education was his main assistant during the experimental work and is now chief filtration engineer at the South District Filtration Plant. In each instance, a chemist was trained to take over plant operation, and the author was able to accomplish much more by having well qualified chemists to assist him.

Why engineering titles often pay more than chemical titles is difficult to understand. The "Chief Filtration Engineer" title in Chicago was once "Chief Filtration Chemist." It was changed largely for salary purposes. Chemistry is an important profession, and a chemical title is just as dignified as an engineering title. With equal pay scales, chemists should not have to be given engineering titles just to earn a higher salary.

Need for Performance Guide

Water that will just pass the USPHS standards should not be considered even a rough indication of good filtration plant operation. The South District Filtration Plant has adopted its own standard, or performance guide, which is so much more rigid than the USPHS standards in bacteriological and turbidity requirements that there is little resemblance between the two. Chicago's standard of bacterial quality does not allow more than one-twentieth the number of coliform organisms allowed by the USPHS standards. The standard of turbidity is 0.1, whereas the USPHS standards allow a maximum of 10. There is a committee recommendation to change the figure to 5. With its own standard, Chicago will reduce the chlorine dosage if the water is much better than the standard. The amount of coagulating chemicals necessary is reduced if the turbidity of the filtered water is zero nearly all the time. Practically all filtration plants would like some more rigid guide to performance than that offered by the USPHS standards. It is, of course, realized that public health officials expect much

better performance results than the maximums of the standard.

There is some hesitance on the part of public health officials to be very exacting in standards of quality for water. Such officials may prefer that the industry adopt its own standard of performance. The need for more rigid control of the water quality is increasing, especially for supplies having some sewage and industrial-waste pollution. So many compounds not thought of years ago are now in some of the surface waters that there should be some incentive to attract more highly trained personnel to water supply. The industry has not advanced much in improving bacteriologic quality in the past 35 years. Chemical advances also have not been great.

Unfiltered Surface Water

Unfiltered surface water is still supplied to millions of water consumers, chlorination being the only means of protection against waterborne disease. Such water supplies should never be rated high. Filtered water supplies with open storage reservoirs on the distribution system should also be penalized considerably.

Recently there has been some unfavorable publicity in the press about danger in water supplies. Conditions are probably not nearly as bad as some of the articles have implied, but the industry should not rise in great indignation until it has carefully examined its water supplies. It is well known among water supply scientists that very few systems offer absolute protection to the water consumer. At one time the bacterial content of the water was almost the only criterion of safety. Very few surface waters have no sewage pollution, even though the pollution may be only that contributed by the birds and a few scattered inhabitants living on the watershed. New compounds, not manufactured years ago, are gaining access to water supplies, and a few of them may be dangerous. The use of insecticides is also on the increase.

At a time when water utilities should be adding highly educated chemists and biologists to their staff, low salaries almost exclude personnel of this capacity. No ambitious chemist or biologist with a Ph.D. degree is likely to remain long in the average water laboratory, directed by an engineer who confines his work almost solely to tests that can be made by a high school graduate.

TABLE 1

Percentage of 10-ml Filtered-Water Samples Showing the Presence of Coliform Bacteria, 1950–59

Year	Positive Samples *per cent*
1950	0.13
1951	0.08
1952	0.20
1953	0.06
1954	0.06
1955	0.09
1956	0.06
1957	0.09
1958	0.00
1959	0.06
Avg	0.083

Practical Value of USPHS Limits

The limits given in the proposed revision of the USPHS Drinking Water Standards seem reasonable for a document of this nature, but in the practical operation of water systems involving

either chlorination alone, or chlorination combined with filtration, not many tests are given much consideration. In fact, for most water supplies, the management looks at only two items, the coliform bacteria, and, in filtration plants, the turbidity of the filtered water. Chlorine is added to the water to cause it to come well within the limits set forth by USPHS. As a matter of fact, a large percentage of the filtration plants produce water of such a low coliform-bacteria content that the standard can hardly be said to serve as a rough guide in the operation.

Is a water utility ever justified in reducing the amount of chlorine being added because the coliform-bacteria content is much lower than the limitation given in the water quality standards of the USPHS? It has been the author's observation that chlorination generally is not reduced until the coliform-bacteria content is less than one-tenth that of the standard. At Chicago, one-twentieth of the coliform bacteria allowable is used as an aim. If the content is less than the one-twentieth of the USPHS limit and averages that day after day, the chlorine dosage is then reduced. It is considered desirable to maintain a certain minimum residual chlorine in the water leaving the filtration plant. This minimum is for protection of the water in the distribution system, the objective being to have some residual chlorine in the entire distribution system. Often the maintenance of this residual produces water of exceptionally high bacterial quality, as is shown in Table 1, but it is still considered advisable not to reduce the residual further.

Table 1 gives the percentage of the 10-ml tubes positive in tests for coliform bacteria in filtered water from the South District Filtration Plant for a period of 10 years. Chicago has set 0.50 per cent positive as its aim for finished water. The figures for plant operation average considerably lower than the aim, as is to be expected because of the residual chlorine maintained. The author does not see how water treatment plants can be operated most efficiently without some aim in view as to the quality of water to produce in order that there be no waste of chemicals in treatment. USPHS requires not more than 10 per cent of the 10 ml tubes positive—a figure so far above what the water filtration plant should produce that it cannot serve as a guide for the operator who is striving to maintain water of truly high bacteriologic quality. Much could be done to bring about better filtration by setting desirable operating goals in addition to limits above which the water would not be approved. At present the operator has nothing to go on, and each operator must decide for himself how much better than the USPHS requirement the water should be.

A discussion of this subject by Elwood L. Bean, chairman of AWWA Committee 2225 M, studying the performance of filtration plants, suggests that much greater refinement of filter performance is needed, particularly in regard to turbidity of the filtered water. It would mean something to say that the turbidity of filtered water should not average more than 0.2—not, as in the USPHS standards, 10, or, as has been proposed, 5.

Conclusion

The author does not wish to cast reflection on the large number of very

capable and dedicated water treatment chemists and chemical engineers. Most of them will continue to render good service, even though their pay is generally lower than that in other industries. Will there be someone as capable to replace them? Interest in the work may overcome some salary differences, but it is not going to attract the best qualified men while salaries are as low as in some water utilities. These utilities bring about conditions that will attract employees of high quality.

——Need for Professional Standard—*Elwood L. Bean*——

A paper presented by Elwood L. Bean, Chief, Treatment Sec., Water Dept., Philadelphia, Pa.

Water quality standards were first discussed by Whipple in the JOURNAL in 1924.[1] Various phases of the subject have been dealt with in numerous publications since. Whipple supported the idea that quality standards should be professional and adopted by the industry—that is, that they should not be governmental, minimum standards, only, being the governmental responsibility. There was much disagreement as to whether the two types of standards should not both be promulgated by governmental agencies. However, as Hudson has written,[2] "the present drinking water standards, adopted 22 years after Whipple set out his views, are set at levels that are scorned by many plant operators, yet there is resistance today against making federal standards more rigid."

Rating Systems

Rating systems are not new; in fact, as early as 1916 USPHS attempted to rate various supplies by a score system. No less than eleven articles were published relative to rating in the following 15 years, and, in 1927, NEWWA adopted a tentative working system. In 1935, Weston advanced the application of this system.[3] In 1940, Baylis proposed five sets of numerical levels for five standards of quality A, B, C, D, and E, the A being a high-quality water, the C being a grade that would be quite unacceptable today, and D and E being still lower.[4]

Always there seems to have been considerable disagreement and little use was made of the systems. Now, however, there seems to be reasonable agreement that standards have value, and that a rating system, properly prepared, might be of real value.

Professional Standards

There seems to be general agreement that there should be professional standards in addition to governmental standards, as the function of the latter is solely the protection of health. Because the latter can be only minimum standards, they have frequently been attacked as promoting mediocrity. Professional standards, on the other hand, can be goals desirable of attainment. There is still no agreement as to the level at which the professional standards should be set—that is, whether they should be entirely unattainable by any water system or attainable by only 10 per cent, 50 per cent, or 90 per cent. If the former one or two policies were adopted, penalties would attach for failure of attainment. (This is parallel to the

method of NBFU). In the other cases bonuses would be applied for quality better than the standard. The former would be goals, or incentives; the latter two would often be only meeting standards. The former policy has now apparently been approved by the AWWA Rating Committee, as is expressed in writing of the Task Group on Accounting:

> The basic idea is to divide each section into a series of factors or requirements and then assign penalty points to each for failure to measure up to the ultimate. The goal is absolute perfection. The penalty deductions for not achieving this absolute perfection will be small. Deductions for not achieving realistically high goals or not maintaining a creditable, above-average standard will be rather large. If the records maintained fail to give adequate coverage, are incomplete or inaccurate, or could result in poor customer service or faulty information, the penalty or deficiency-point deductions will be very severe.

Inadequacy of USPHS Standards

It is believed that water utility men are hampered by the low requirements of USPHS, which is the only standard in the United States. Laymen and politicians cite this standard and say there is no need for improvement. High standards would give utility management a point of argument for better facilities for producing better water.

The author believes that a high water utility performance standard would:

1. Be a document water utility men could cite to prove the need for bettering their facilities.
2. Place an added pressure on water systems to improve quality.
3. Be an aid to USPHS in enforcing its standard.
4. Cause a general improvement in water quality.
5. Tend to raise the standing of the water supply profession.
6. Please the majority of water utility men.

Industrial and Domestic Needs

There is agreement in the AWWA committee that professional standards should be written primarily for public water supplies, with the household consumer in mind. Water suitable for the household consumer will be suitable to most industries without change. If not, industries may readily prepare it for their purposes by a single filtration or adjustment. The thoughts expressed by McKee [5] should be kept in mind:

> Water works engineers must give increasing attention to the primary need of industry for water of a quality that remains relatively constant over reasonable periods of time. Most industries are willing to accept municipal water that meets drinking water standards, with the recognition that this water must be altered for specific purposes such as boiler feed, cooling, or process water. Industry is quite prepared to accept and further treat municipal water, provided that such water is not subject to sudden changes in quality.

Point of Applicability

Water quality standards have generally been considered applicable to water as delivered into the distribution system. This is being changed in the new standard, as indicated by a statement approved at a Mar. 9, 1960, meeting:

> The Advisory Committee on Revision of the 1946 Public Health Service Drinking Water Standards, recognizing the desirability of interchange of information and opinion with the American Water

Works Association Committee on Standards of Water Quality (Task Group 2225 M), would like to express the urgent hope that the AWWA committee will choose to express its selected quality standards for water *at the consumer's tap*. Since the revised USPHS Drinking Water Standards are expected to apply to representative samples of water from the distribution system, it is strongly urged that, if possible, the two sets of standards, expected to be in wide use in the industry, be referred to water sampled at similar points.

Question was immediately raised regarding the wording "at the consumer's tap," as in some systems 70 per cent of complaints are caused by piping, groundings, or cross connections within the consumer's premises. It seems, however, that the wording of the statement was not entirely in accord with the committee's thoughts, for the proceedings of the committee state:

> Responsibility for conditions in the water supply system shall be considered as follows: (a) *The water purveyor* from the source of supply *to the connection to the consumer's service piping;* (b) The *owner of the property* served in the municipal, county, or other authority having legal jurisdiction *from the point of connection to the customer's service piping to the free-flowing outlet of the ultimate consumer.*

The basic thought is that "the water supply system, in all its parts, should be free from health hazards." Standards based on the distribution system delivery to the consumer, if inflexible and subject to enforcement, would need to be markedly different, in some items, from standards for treatment plant effluents. For this reason, Hudson has suggested the possibility of two separate standards, one for each location. He has stated:

> The grading scheme for water quality on the plant effluent would tell whether the plant was doing a good job. A second application of a less restrictive grading schedule to water taken from the distribution system would not grade water quality, but would grade the distribution system and, therefore, might be worked in combination with the distribution system grading scheme.

The author's own reaction to this suggestion is to question the advisability of a third set of standards.

Functional Aims of Standard

It is agreed that a statement of functional aims should precede any statement of specific requirements as to limits of concentration. The wording of such a statement is still in formative state. Two suggested versions are:

1. Ideally, water delivered to the consumer should be clear, colorless, tasteless, and odorless. It should be free from biologic forms which may be harmful to human health or aesthetically objectionable. It should not contain concentrations of chemicals which may be physiologically harmful, aesthetically objectionable, or economically damaging. The water should not be corrosive or incrusting to or leave deposits on water-conveying structures through which it passes, including pipes, tanks, hot-water heaters, or plumbing fixtures.

Relatively few waters could meet such a specification. We do not even have the knowledge or means in all cases to determine whether a given water meets such a specification. Although water technology and knowledge of the significance of water contaminants, both biological and chemical, is increasing, it is far from complete. However, on the

basis of present knowledge, a water would approach the above defined ideal if it meets the following specifications.

2. The treatment of water shall be such as to produce a quality that is well suited to public supply purposes. The water shall be substantially free of taste, odor, turbidity, and color. Toxic and other objectionable substances shall be below the levels that will cause impairment of health in humans and domestic animals when considered in relation to the total intake of these materials in water and from other sources. The water shall not be corrosive to ferrous, concrete, brass, or bronze materials. It shall not cause impairment of distribution, transmission, and ordinary household facilities, including hot-water heaters and storage tanks. The water shall contain no pathogenic organisms, and the quality shall be so controlled that at all times it is above suspicion as a vehicle for causing disease.

Areas of Standardization

There is some question as to what areas standards should cover. There are probably hundreds of possible items; approximately 60 are commonly used as determiners of quality. Some of the fields requiring major study and consideration are indicated below:

1. It is proposed that arsenic, cyanide, hexavalent chromium, lead, barium, selenium, and cadmium, all of which are known to be toxic and therefore are included in the USPHS standard, be either omitted from a professional standard or included only on a basis of requiring conformance to the USPHS standard.

2. It is proposed that the professional standards should deal only with a few items in which high standards are not specifically the responsibility of the USPHS, as they are not justifiable on the basis of health implications. (These might be such as turbidity, color, odor or taste, precipitable anions and cations, and the solids-alkalinity-pH balance.)

3. What are the best means of covering the problem of detergents, which is becoming widespread? Rapid determination is not simple or truly accurate and information is limited. Carbon filter absorption is quantitative, but slow and cumbersome. Also, which of the solvents should be considered most truly yielding the ABS material on test?

4. Which of the myriad pesticides should be considered, and what ranges should be tolerated?

5. What bases are to be used for bacteriologic tests? New USPHS standards will give equal consideration to the fermentation tube methods and to the membrane filter method. With the former, only "completed tests" will be recognized in the requirements statement. Many operators feel that the presumptive positive tests are of great value in indicating some form of organism pollution even though they do not identify any specific organism.

6. What is a workable standard of odor? It seems that some definite scale of values, such as threshold odor, is necessary to be workable, although specifications of "absent" and "no change on carbon contact" have been proposed. If the threshold odor is used what should be the parameter of an ideal water? Even a threshold odor of 1 represents some odor, and ideally there should be no odor.

7. There are 76 types of viruses now known to be pathogenic to humans. It is impossible to culture some of them, and few can be proved pres-

ent, or absent, in water at water plant installations. Should a free chlorine residual, to destroy these, be required in an ideal water? If so, should the required residual take the form of a major or super residual in the treatment plant, to be converted to amine before distribution, or of lesser free residuals to be maintained to the consumer's tap? What residuals, for what periods, should be considered as proof of virus destruction?

8. For elimination of attack on piping, generally considered a matter of proper pH, alkalinity, carbonate, hardness, and solids control, should Langelier's saturation index or Ryznar's stability index be used or some other method of control be originated?

These are but a few of the most difficult areas in which satisfactory solutions must be derived before a worthy set of professional standards can be assembled.

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Legal Viewpoint—*Frank E. Maloney*

A paper presented by Frank E. Maloney, Dean & Prof. of Law, College of Law, Univ. of Florida, Gainesville, Fla.

At the turn of the century, the Mississippi Supreme Court took the position that it is "not necessary to weigh with tenderness and care the testimony of experts" in determining what constitutes wholesome water, as "an ordinary mortal knows whether water is fit to drink and use."[1] As late as 1935, the North Carolina Supreme Court, in an opinion refusing to enjoin a municipality from discharging sewage into a river from which another municipality was taking its water supply, based its decision in part on the fact that the trial judge "had drunk of the water, bathed in it, and suffered no ill effects."[2]

Fortunately, the courts have not remained impervious to the scientific evidence being amassed by sanitary engineers. One result of this scientific study has been the development of drinking water standards by USPHS. Originally promulgated in 1925, they were revised in 1942 and 1946, and another proposed revision is now under consideration. These standards have earned the acceptance of AWWA.[3]

What enforceable legal effect do the standards have? Technically they are applicable only to water used on interstate carriers subject to federal quarantine regulations,[4] but, as a result of their endorsement by so many national organizations concerned with water supply and public health, they have had a tremendous impact throughout the United States.

Public Health Legislation

AWWA's recommendation that the USPHS Drinking Water Standards be accepted as the criterion of quality for all public water supplies in the United States has led to their use as guides in the enactment of legislation by many states. Such legislation has been generally approved by the courts as being within the exercise of police power for the protection of public health.[5-8] The state legislatures have often delegated authority for promulgation of detailed standards to a state administrative agency also clothed with the authority to enforce such regulations. Thus, for example, the Florida State Board of Health has been given power to promulgate rules and regulations with respect to drinking-water standards and practices,[9] and has the legal authority to seek injunctions against the furnishing of impure and dangerous water.[10, 11]

The state boards of health are the customary agencies for maintaining state health programs and implementing the water regulations. These state boards, in turn, work closely with USPHS and are the beneficiaries of the extensive research and investigations carried on by the latter. Through legislation giving approval powers for new projects to the state boards, sanitary engineers, applying the USPHS standards, have revolutionized small-town water utility construction and operation. In backstopping this authority, the courts have upheld, as a valid exercise of the police power, legislation authorizing a state board to prohibit the use of water "so impure as to endanger the public health." [12] On the other hand, an enactment requiring the refusal of a permit unless the supply was "the purest and most healthful obtainable," was held unconstitutional, as the protection of public health does not necessarily require the purest and most healthful of all possible supplies.[13] The USPHS standards do not attempt to go this far. They quite wisely differentiate between certain nontoxic but objectionable chemical substances and toxic chemicals, such as lead, arsenic, and selenium. The standards provide that the nontoxic substances should preferably not be permitted in excess of stated concentrations where other more suitable supplies are available, but permit a much higher solids content if such water is not available. If, on the other hand, the toxic chemicals occur in excess of stated amounts, their presence constitutes grounds for rejection of the supply.[13a]

One other feature of the standards is worthy of note. Although forbidding excessive concentrations of bacteria, particularly of the coliform group, and providing for adequate protection by artificial treatment, the standards do not attempt to spell out exact methods for such treatment. This is a wise precaution, in view of the position of the courts that a state board may not direct a water utility to install any particular type of plant for the treatment of its water, so long as it uses a method that produces water of the required quality.[11]

In addition to the state boards of health, municipal corporations may enact ordinances relating to water supply and its freedom from contamination.[14] The test of the validity of such ordinances is whether they are necessary for the protection of public health.[6, 8, 13, 15] Thus the Florida Supreme Court, in a relatively early case

involving the reasonableness of an ordinance designed to protect the water supply of the city of Miami, held that it was beyond the power of the municipality to forbid the sale of all water containing more than 300 ppm magnesium or sodium chloride, unless it could be shown as a matter of hygienic fact that such water was unwholesome and unfit for human use. As the court said, "The force of the ordinance must rest upon the accuracy of the standard." [16] The court further indicated that the ordinance could not be enforced against a purveyor whose franchise antedated its enactment, if water with the designated chloride content was "merely unpalatable" rather than "impure and unwholesome." It is interesting to note that the present USPHS standards contain a recommendation that chloride content should preferably not exceed 250 ppm, but the line is drawn, so far as absolute prohibition is concerned, at "a total solids content of 1,000 ppm." [16a] This case suggests that it may be difficult to enforce any new standards against water utilities with franchises already in existence when the standards are promulgated, and this may be particularly true where the charter of a company simply calls for it to supply "reasonably pure and wholesome water," a term open to considerable variation in interpretation by the courts.[16b, 17-22]

The USPHS standards will have considerably greater effect if used as a guide in determining whether to grant new charters, or if compliance is made a specific requirement for the retention of a charter by a new utility. Moreover, the scientific experimentation of USPHS which has preceded the promulgation of the standards, the care with which the latter have been drafted, and the many court decisions supporting their use all become evidence of their reasonable relationship to the protection of public health. This should encourage adoption of the standards, without substantial modification, by a state board interested in improving the quality of the drinking water supplied in its state.

Fluoridation Litigation

It is interesting to note that most of the litigation in the drinking-water field has centered on something not required by the USPHS, fluoridation. Addition of fluorides to drinking water, although amply justified as a public health measure to strengthen the teeth of the younger generation, has been attacked on every conceivable ground. It has been argued that addition of fluorides exceeds the police power, denies freedom of religion to those who believe that medication is sinful, violates the personal liberty of individuals to treat their health as they deem best, violates the personal liberty of parents to rear and care for their children as they deem best, and the right to be free of medical experimentation on one's person. It has been further argued that states have no power to delegate authority to municipalities to pass legislation concerning public health, that such delegation constitutes an unlawful authorization to public utilities to practice medicine, denitstry, and pharmacy, and that such ordinances conflict with state and federal laws prohibiting the adulteration of food.[23] Fortunately, the courts have had the good sense to reject all of these arguments on the basis that the freedoms claimed must yield to a public health measure de-

termined to be necessary and adopted for the common good of the public.[24-27] The fluoridation statutes have been upheld as a lawful exercise of the police power in the best interests of the public. Despite the plethora of litigation and legal literature,[28-33] thus far no court has prohibited fluoridation, a fact which speaks well for the care with which the program was developed.

The lack of a requirement for fluoridation in the standards again points up their prohibitory rather than mandatory nature. They merely set the maximum permissible level of fluorides. Consequently, the attorney general of Florida has advised that the Florida State Board of Health, acting under a similar set of standards, has no responsibility as to fluoridation except to prevent such fluoridation from becoming a menace to public health.[34]

Liability for Negligence

It may be helpful to evaluate briefly the potential areas of civil liability of water purveyors, and the ways in which compliance with the USPHS Drinking Water Standards, including the proposed new revision, can be used to minimize such liability. One of the legal bases for liability for supplying unsafe drinking water is negligence of the supplier.

A supplier of drinking water may be held liable for negligence if he falls below the standard of good practice in supplying the water and the consumer is thereby injured.[35, 36] Proof that such injury was caused by the water supply may be difficult,[37-40] but injured individuals have succeeded in a number of cases of waterborne diseases such as typhoid, and enough other users have been similarly affected to justify submission of the facts to a jury to determine whether there was a reasonable inference that the disease resulted from consumption of contaminated water.[19, 37, 41-45]

The standard of conduct in negligence cases may be arrived at by the courts in one of two ways: through the so-called common-law approach of determining what a reasonable man would do under the circumstances, or by looking to legislation to establish the required standard. Liability in most of the early water cases was based strictly on common-law principles. The water purveyor was held to a standard of conduct based on what a reasonable man, possessed of a minimum of knowledge and skill common to the industry in the locality, would do in the light of the foreseeability of possible harm, balanced against the social value of the course pursued. To be held liable, the supplier need not have actual knowledge of the unwholesomeness of the water he dispensed, if a reasonable man with his purported knowledge of the business would have discovered the dangerous condition.[46] As stated in a 1914 Connecticut case [47]:

> [I]t [the purveyor] is bound to use reasonable care in ascertaining whether there is a reasonable probability that its water supply may be infected with a communicable disease from causes which are known to exist, or which could have been known or foreseen by the exercise of such care; and if the exercise of such care would have disclosed a reasonable probability of such infection, then it becomes the duty of a water company to adopt whatever approved precautionary measures are, under the circumstances of the case, reasonably proper and necessary to protect the community which it serves from the risk of infection.

In common-law negligence cases the jury under proper instructions is normally the final arbiter of what a reasonable man would have done in the circumstances of an individual case. In the Connecticut case referred to above, the supreme court of that state held that when there was a typhoid epidemic in town there was sufficient evidence to go to a jury on the question whether the water utility was negligent in not properly treating or examining the water in its reservoir before distributing it.

In addition to the common-law approach of using the conduct of the hypothetical reasonable man as the standard of care, the courts have developed an alternative method, based on legislative enactment, of arriving at the standard. This method is widely used in automobile negligence cases, in which violation of the motor vehicle laws is perhaps the most common basis for establishing driver negligence.[48] The statutes employed are usually penal in character and do not, on their face, impose civil liability, but the courts use them to establish the standard of care.[49] One ground for this use of such statutes is that the legislation in question, enacted after much study, is the best evidence of what is reasonable, and, therefore, one who violates such enactments is not acting as a reasonable man and is therefore acting negligently.

As explained in an early Minnesota case[50]:

> Negligence is the breach of legal duty. It is immaterial whether the duty is one imposed by the rule of common law requiring the exercise of ordinary care not to injure another, or is imposed by a statute designed for the protection of others. . . . The only difference is that in the one case the measure of legal duty is to be determined upon common-law principles, while in the other the statute fixes it, so that the violation of the statute constitutes conclusive evidence of negligence, or, in other words, negligence *per se*.

Not all courts agree that such statutes conclusively set the standard, but the case does indicate the generally prevailing attitude. Even in jurisdictions which do regard statutory violation as conclusive evidence of negligence, however, violations of municipal ordinances or the regulations of administrative boards are often looked upon only as some evidence of negligence, to be evaluated by the jury, rather than as conclusive evidence.[51-53]

No cases were found in which the courts used the USPHS Drinking Water Standards or similar state drinking water standards to establish a legislative standard of care in water supply cases, although the standards were discussed in at least one case.[54] The frequency with which legislation is used to set the standard in other types of negligence cases, however, suggests that such use of drinking water standards in water supply cases may well be made by the courts in the future. If promulgated by a state board of health or by municipal ordinance, they may not be given the same weight as if directly enacted by the legislature, but they may still be very potent weapons for establishing the negligence of a purveyor who has failed to comply with them.

Even in the absence of their use in setting a legislative standard of care, the standards, particularly the proposed new revision, may serve another purpose. They may be used to change or update the standard of care to which water purveyors will be held by the courts. The customary conduct of an

industry in an area is very persuasive evidence of what is reasonable conduct. But, as stated by Justice Lerned Hand in an early case discussing the failure of coastwise-tugboat operators to install radio equipment capable of receiving weather reports [55]:

> Is it then a final answer that the business had not yet generally adopted receiving sets? There are, no doubt, cases where courts seem to make the general practice of the calling the standard of proper diligence; we have indeed given some currency to the notion ourselves. . . . Indeed, in most cases reasonable prudence is, in fact, common prudence; but strictly it is never its measure; a whole calling may have unduly lagged in the adoption of new and available devices. It never may set its own tests, however persuasive be its usages. Courts must in the end say what is required; there are precautions so imperative that even their universal disregard will not excuse their omission.

The new drinking water standards when adopted by USPHS, should become strong evidence of what is required to meet the legal standard of care, and it is reasonable to assume the courts will use them for that purpose. On the other hand, proof by a water purveyor of compliance with the standard will be the best possible evidence that he has lived up to the standard of good practice and thus cannot be charged with failure to take proper precautions.

Liability for Implied Warranty

Another approach to liability that has been gaining widespread acceptance in recent years, in cases involving suppliers of products such as machinery, food, and drugs, is the doctrine of implied warranty.[56] According to this doctrine, when a purchaser of goods relies on a seller's skill and judgment in making his purchase, and has made known to the seller the purpose for which the goods are required, the sale gives rise to an implied warranty or promise on the part of the seller that the goods are reasonably fit for the purpose for which they are purchased. If the purchaser is injured because of a lack of such fitness, the seller is liable, regardless of whether or not he was negligent, so long as the vendor has had an opportunity to examine the article sold.

Is this doctrine applicable to the supplying of drinking water? The New York Court of Appeals in a 1920 case took the position that it was not, on the ground that a homeowner whose children had contracted typhoid fever from the defendant purveyor's drinking water had not made known to the purveyor the particular purpose for which the water was required.[57] The case has been cited as a leading case for the position that the implied-warranty doctrine is inapplicable to water purveyors.[58] But the logic of the position that the purveyor did not know that at least some of the water was purchased for drinking is open to considerable question, and the decision was supported only by a bare majority of the New York court.

The doctrine of implied warranty was used as an alternative basis of liability in a 1939 Massachusetts case,[54] and, in view of the current widespread movement by the courts to find implied warranties of fitness in food consumer cases,[56] it would be rash to predict that the doctrine will not be extended to more drinking water cases in the coming years.

If such a trend does develop, what part will the USPHS Drinking Water Standards play in the application of

the implied-warranty doctrine? It should be noted that the implied warranty most often employed, the warranty of fitness, is usually taken from a state statute adopting the Uniform Sales Act. This warranty, as set forth in the act, is that the goods "shall be reasonably fit" for the purpose for which purchased.[59] If the water in question complies with USPHS standards, a strong argument can be made that it is reasonably fit.

In the one Massachusetts case in which the doctrine was applied to drinking water, the court placed considerable emphasis on the fact that the water, which contained more than 4 ppm lead, fell below the USPHS standards, which set the maximum safe level for lead at 0.3 ppm.

Thus, compliance with the USPHS standards may arguably provide a defense to an action based on implied warranty as well as negligence. The validity of this argument will not be known until more warranty cases have been evaluated by the courts, and it should be noted that the word "reasonable" has been dropped in the description of the warranty of fitness in the Uniform Commercial Code,[60] which is slowly replacing the Uniform Sales Act. At the present time, however, compliance with the standards would seem to provide the best available line of defense against liability based on implied warranty.

Conclusion

The present widespread respect for the USPHS Drinking Water Standards would seem to dictate caution in recommending drastic modification, unless it is clearly necessary for the further protection of the public health. It seems clear that with the growing industrial use of new contaminants, such as radionuclides and synthetic organic compounds, the standards will have to be modified to include prohibitions against the presence of these contaminants in concentrations above limits that can be established as harmful by clear scientific evidence. If such evidence is available, there should be little difficulty in obtaining acceptance of such modifications by the courts. But the very respect with which the present standards are now regarded would suggest that only such changes be made as can be clearly justified, so that that respect may be retained and strengthened.

As Abel Wolman has recently pointed out, "in this period [the past 75 years] the improved sanitary quality of the public supplies has brought about one of the most dramatic improvements in public health that the world has ever known."[61] Widespread adoption of the USPHS Drinking Water Standards has been a major factor in this victory. Recognizing this fact, our courts must and will support the efforts of USPHS to keep the standards abreast of the times.

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Low-Temperature Liquid Lime Slaking at Howard Bend Treatment Plant

William B. Schworm

A paper presented on Apr. 6, 1960, at the Conference on Water Softening and Stabilization of Softened Water (cosponsored by the Missouri Section of AWWA and the Univ. of Missouri), Columbia, Mo., by William B. Schworm, Sr. Chem. Engr., St. Louis Water Div., Howard Bend Station, Chesterfield, Mo.

MORE than 50 years have passed since the lime slakers used at Chain of Rocks, Mo., were installed. The design of these slakers was based on experiments in slaking lime conducted by W. F. Montfort.[1] He established, through the use of live steam in heating the slaking water to 160°F, that maximum efficiency in slaking could be obtained by maintaining the temperature in the slaker tank at approximately 206°F. Montfort found that 1 lb of lime required a minimum of 3.5 lb of water to remain in a fluid condition.

The heat exchangers, which were subsequently made part of the slaker equipment, were designed to allow the heat of the reaction to be transferred in part to the slaking water by means of copper pipe. Montfort's work remained the basis for the design of the slakers installed in 1929 at the Howard Bend Station in Chesterfield, Mo.

In 1936, Hartung and Lischer,[2] in an attempt to find reliable specifications for the use of lime slakers, started a series of laboratory experiments with vertical- and rotary-fired lime. They specified a slaking temperature of 180°F and a detention time of 30 min. They also concluded that the nearer the temperature in the slaker is to boiling, the faster is the slaking. H. E. Lordley,[3] in his studies on lime slaking at Richmond, Va., installed electric immersion heaters in the slaking water to raise its temperature higher than 160°F in the slaker.

In planning for the expansion of facilities at Chain of Rocks to include a high-service, as well as a low-service, pumping station, it was decided to purchase electric power to run the pumps. This called for the eventual elimination of the steam plant, with a consequent discontinuance of the use of process steam. Thus, no steam would be available for auxiliary use in heating the water from the heat exchangers to the proper temperature in the wintertime. The purpose of the tests to be described was to determine whether lime could be slaked efficiently at low temperatures, without the use of heat exchangers, with cold water, and with the temperature of the slaker controlled by the rate of flow of tap water to the tank.

Use of Slakers

The slakers in use at Howard Bend were fitted with stationary mixing paddles at the top of the tank. A water

jet was installed at the overflow outlet to break up lumps of slaked lime and to facilitate flow from the slaker. The method chosen was to alternate the use of heat exchanger and steam with normal flow of slaking water, as opposed to the use of the slaker alone without heat exchanger or steam and with a decreased flow of the slaking water.

by observing the effect of the reaction of the lime with the alkalinity present in the raw water in the primary conditioner. The effect of the reaction would be indicated by the total alkalinity. The smallest concentration of alkalinity at any given time would be a measure of the maximum reaction of lime with the alkalinity present in the raw water. In former years, with

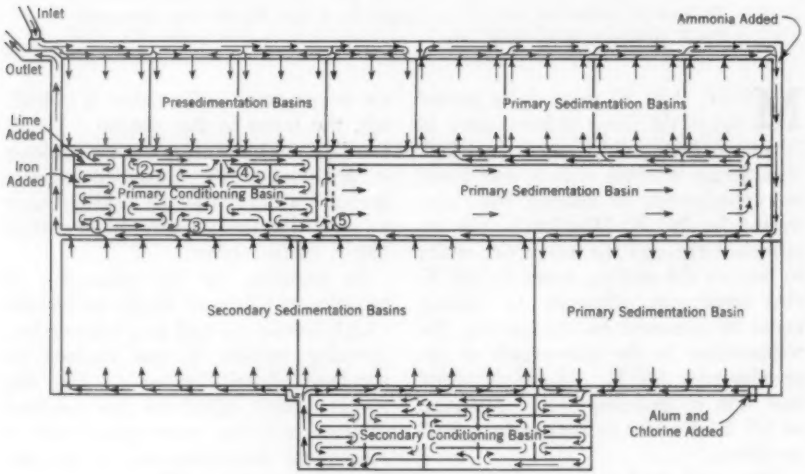

Fig. 1. Operations at Howard Bend Treatment Plant

Samples for the alkalinity tests were taken daily from the numbered points shown in the primary conditioning basin.

Each method was alternately tried for a period of approximately 2 weeks. In starting up the tanks in which no auxiliary steam was to be used, the tank water was first heated with steam to eliminate initial overtreatment in the primary conditioner. When the tank reached a temperature of 140°F, the steam was discontinued.

It was thought that the best way to check the efficiency of the slakers was an additional variable of fluctuating turbidity, this observation would not have been as conclusive. For the past several years, since the opening of the large main-stem dams, the concentration of turbidity in the river has been quite small and the alkalinity fairly constant, particularly during the winter. For these reasons, the selection of total alkalinity as a parameter was believed to be justified.

Alkalinity Tests

Samples were taken daily from the primary conditioning basin at the numbered points shown in Fig. 1. Table 1 shows the conditions under which the slakers operated for the period of the test. It will be noted that a considerable reduction in the rate of flow from the slaker must be maintained when the slaker temperature is low. This is necessary to keep the temperature of the slaker as high as possible. As the tap temperature becomes warmer, the control of slaker temperature becomes easier.

The results of the alkalinity tests of samples taken from the primary conditioning basin (Fig. 1) during the periods shown in Table 1 are plotted against time in Fig. 2 and 3. Fig. 2 also shows the temperature of the river water during the test period. An examination of these figures reveals that the solid lines representing times when the heat exchanger and steam were not used are nearly all below the dashed lines representing times when the heat exchanger and steam were used. This shows that no lime is lost in the primary conditioner and that the lime was properly slaked.

The following year it was felt that a continuation of the test period throughout the winter of 1958–59 would be valuable in substantiating the preliminary conclusions made during the previous winter. Data for the additional tests are shown in Table 2. They do not show any marked variation from the data in Table 1 for approximately the same tap temperatures. No variation in alkalinity in the daily samples was noted in the primary conditioner when the heat exchanger was on, as opposed to when the heat exchanger was off. It would seem, then, that the conclusions of the previous year were correct and that this type of rotary-fired and properly sized lime can be slaked efficiently at low temperatures.

TABLE 1

Water Temperature and Flow Rate During Preliminary Alkalinity Tests

Test Period—*1958*	Tap Temperature °F	Heat Exchanger Temperature °F	Slaker Temperature °F	Rate of Flow From Slaker *gpm*
Jan. 15–27	44	89	191	22
Jan. 28–Feb. 8	41	—*	146	9
Feb. 11–24	40	85	192	22
Feb. 25–Mar. 10	44	—*	149	12
Mar. 11–31	44	73	193	19
Mar. 24–Apr. 4	53	—*	149	12
Apr. 8–18	62	101	195	29
Apr. 21–May 5	66	—*	152	13
May 5–12	67	107	190	18
May 13–23	76	—*	152	16

* Heat exchanger not used.

Use of Lime

The fact that the temperature of slaking is considerably lower than recommended by Montfort, Hartung, and

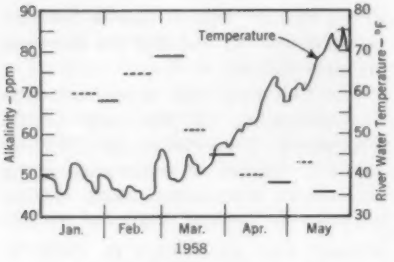

Fig. 2. Alkalinity of Samples From Point 1

The samples tested were taken from Point 1 in the primary conditioning basin shown in Fig. 1. Solid lines represent periods when the heat exchanger and steam were not used; dashed lines, when they were used. Tests were made during the period Jan. 15–May 23, 1958 (Table 1).

others might raise some questions. All of Montfort's, and part of Hartung's, tests were made on vertical-fired lime; their conclusions for this type of lime were valid. Most of the lime used at that time was made in coal-fired vertical kilns with large stones that were crushed after firing. The large size and uneven heat of the coal-fired kiln resulted in overburning on the outside of the stone and underburning at the center. This type of lime would naturally require more time and higher temperatures to slake properly. There would be more dead-burned and underburned insolubles. Modern practice of lime burning calls for properly sized stone before burning in rotary-fired kilns, which are heated with gas or powdered coal. The control of heat

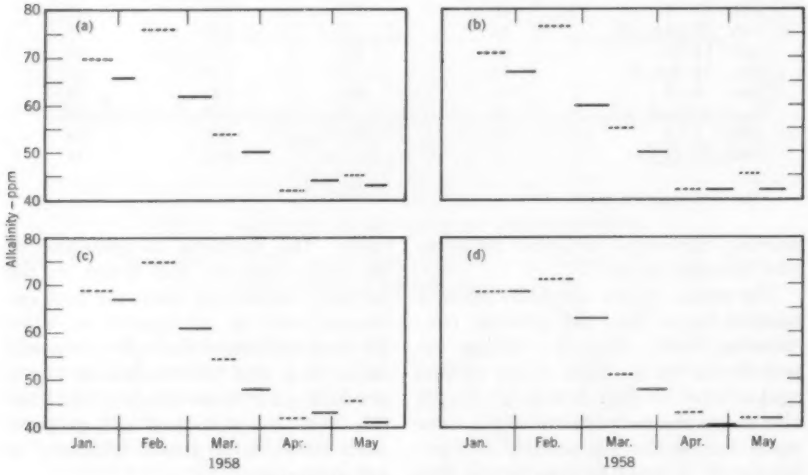

Fig. 3. Alkalinity of Samples From Points 2–5

The samples tested were taken from Points 2–5 (a–d, *respectively*) *in the primary conditioning basin shown in Fig. 1. Solid lines represent periods when the heat exchanger and steam were not used; dashed lines, when they were used. Tests were made during the period Jan. 15–May 23, 1958 (Table 1).*

in these kilns is precise, and lime produced by them will slake quickly, with explosive force. In doing so, it disintegrates rapidly to a fine slurry, requiring less slaking water and lower temperatures.

During the period shown in Table 2, heavy charges of lime were used, as much as 137 ppm, with no noticeable difference in slaking. From the results of the 2-year study at Howard Bend, it seems possible to design a fluid-type slaker that will operate at low temperatures and with large charges of lime. This opinion, however, holds only for the high-heat, rotary-burned lime that is small in size and fast slaking—the kind of lime now being used at Howard Bend. Another kind of lime would require a new experiment that would, perhaps, lead to different conclusions.

TABLE 2

Water Temperature and Flow Rate During Additional Alkalinity Tests

Test Period	Tap Temperature °F	Heat Exchanger Temperature °F	Slaker Temperature °F	Rate of Flow From Slaker gpm
Nov. 1–Dec. 1, 1958	56	—*	137	17
Dec. 2, 1958–Jan. 12, 1959	42	84	192	23
Jan. 13–Mar. 31, 1959	45	—*	148	12
Apr. 1–May 16, 1959	66	93	192	25

* Heat exchanger not used.

Operations

A new design of slakers should provide for the use of electric heaters for initial heating (start-up) and a mechanism for continuous removal of insolubles. Perhaps with improved placement of paddles and baffles, the slaker could be made to operate more efficiently. Some thought should be given to the design of the eductors or jets at the discharge end, to allow the lime to be drawn from the tank more efficiently.

Except for the normal apprehension that goes with any plant experiment, no operating difficulties were encountered. It was soon learned that the tank could not be heated solely by the heat of hydration at the start of the run. This method caused the slurry to become too thick and resulted in overtreatment for a period of hours.

The present method of starting up a new slaker is to fill the tank with water the day before to allow it to reach room temperature. Steam is then applied to raise the temperature of the water to 140°F. This method has been entirely satisfactory. At the same time that a new slaker is placed in service, the old slaker is purged with water for several hours to wash out the soluble portion of lime trapped in the bottom sludge.

Tanks operated at low temperature seem to run longer between cleanings. At present, such tanks run for 30 days, as compared with a run of 2 weeks with high-temperature operation. This difference may be the result of the ability of thicker, low-temperature slurry to suspend particles that then flow out with the lime. It was also

noted that the tanks do not build up a hard layer of dense lime on the sides and paddles. The bypassing of the heat exchanger six times a day for flushing is also eliminated. There are no heat exchangers to clean and maintain.

Conclusions

With the high-heat, fast-slaking, rotary-burned lime now being used at Howard Bend, slaking can be accomplished at lower temperatures. It should be possible to design a more efficient fluid-type mechanism to slake lime of this type. It should be emphasized that these conclusions are valid only for this kind of lime.

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Handling of Phosphates at Torresdale Treatment Plant

Vincent B. Janson

A contribution to the Journal by Vincent B. Janson, Philadelphia Dist. Sales Engr., Tote System, Beatrice, Neb.

THE Torresdale plant in Philadelphia, a modern rapid sand filter plant, is second in size only to Chicago's 480-mgd treatment plant. With a maximum capacity of 423 mgd, the plant is presently more than adequate for the demand of 160–170 mil gal called for on a typical day. This capacity far exceeds the typical summer demand of 210 mgd and the peak demand of 250 mgd during hot weather. It is anticipated that the Torresdale plant, and the subsequent modernization and improvement of other Philadelphia water treatment facilities, will provide for the growing demand expected in the next 35 years. In 1962, Torresdale's supplies and those of the modernized Queen Lane plant will allow for the closing down of the old Roxborough plant. The Queen Lane modernization will be completed in 1960, and new express mains, to be ready by 1962, will permit Torresdale and Queen Lane to take over the area served by Roxborough.

Use of Bins

The new $25,000,000, rapid sand filter plant, 5 years in the building, includes preliminary and post-treatment facilities. Unique in many ways, its post-treatment facilities incorporate a method of phosphate handling new to treatment plants. Discarding older time-consuming methods of phosphate handling and introduction, Philadelphia handles all the preventive chemicals in bins*—large aluminum containers that act as shipping containers from supplier to user; as storage units near the point of use; and as discharge hoppers when used in conjunction with a special tilt,* a discharge mechanism that tilts the bins on a 45-deg angle for materials flowout.

The use of this bulk-handling method at Torresdale probably marks the first time it has been used in a water treatment plant. For over a decade, similar airtight aluminum and steel bins have been used throughout industry; in the bakery field, for example, for the handling of flour and sugar and, later, for the handling of any dry bulk material. In 1958, 300-gal and 400-gal bins were developed for the handling and storage of liquids.

The 34 bins at Torresdale, which are used for basic handling operations—shipping, storage, and discharge—each hold about 2 tons of pelleted metaphosphates. The phosphates are shipped on open flatbed trucks to the plant from the chemical supplier in Rumford, N.J. At the plant, they are

* Product of Tote System, Beatrice, Neb.

removed from the truck by a fork lift at the post-treatment building loading dock. Empty bins are trucked back for refilling. The full containers are conveyed by elevator to the discharge-storage area, where they are double-tiered to save space (Fig. 1). The tiered bins are stored only a few dozen feet from the dual-tilt discharge station, and can be moved to the discharge area and put in position in a matter of minutes. This operation constitutes almost all the labor necessary, as the plant requires a little less than a full bin a day to provide the 1 ppm of phosphate required for effective water treatment.

Fig. 1. Phosphate Bins in Storage Area

The aluminum bins each hold approximately 2 tons of phosphate. The bins have airtight seals that keep the pelleted phosphate dry.

Savings

As the plant itself is completely new and of a radically different design than the former slow sand filter plant, there is no basis for comparison of labor or cost savings between the two plants. By using the bins, however, Philadelphia eliminates the cost of plastic-lined multiwall bags that held only 100 lb of phosphates. Thus, every bin saves the cost of 40 such bags. The new operation also eliminates the time spent in slitting, dumping, and scrapping of 100-lb multiwalls, as well as maintenance and cleanup time. Furthermore, the saving of space inside the plant, because the bins can be tiered, and the advantage of being able to store the bins out of doors if necessary, are other factors to be considered in the modern plant setup.

One truck turnaround handles the phosphate requirements for Torresdale. Empties are transported by truck for filling, and the full bins are returned the following week. The open

truck, instead of a covered trailer, used for shipping allows for savings in maintenance, and the airtight seal of the bins protects the hygroscopic pellets from deterioration. The material remains sealed until the bin is placed on one of the two tilts at the Torresdale plant.

in the piping system and to reduce to a minimum the complaints about rusty water, are increased or decreased according to the requirement of the system. Presently, Torresdale has determined that 1 ppm is sufficient. The water is maintained at a pH of 7.5 for best phosphate performance.

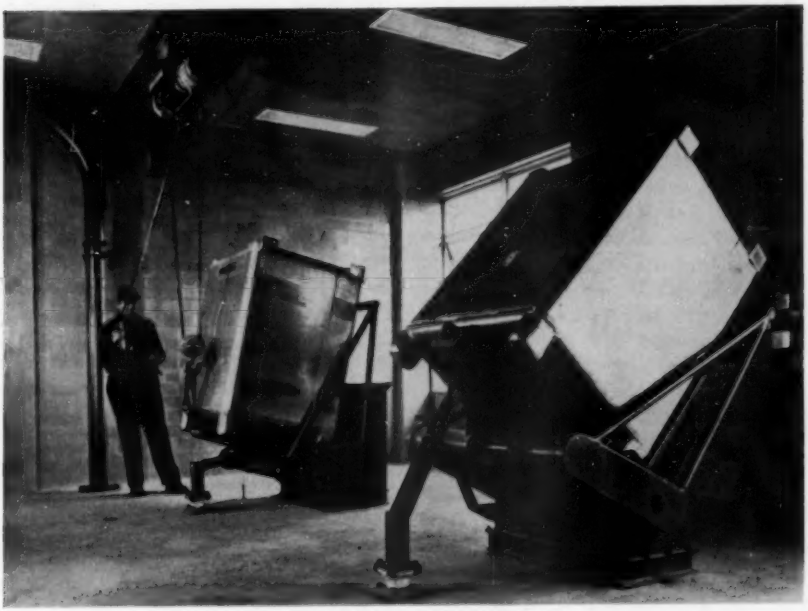


Fig. 2. Phosphate Bins on Tilts

The bins, taken from the storage area only a few feet away from the tilts, are readied for gravity dump in a matter of minutes. The bin in the foreground is being emptied. The phosphate flows into a mixing tank on the floor below.

Use of Tilts

One of the two tilts at Torresdale is a spare, to be used if the other tilt breaks down. The extra tilt also would be used in conjunction with the other if Torresdale were to increase the phosphate concentration to 2 ppm. Phosphates, used to prevent corrosion

The second tilt also could be used on peak demand days. The tilts feed into two mixing tanks, located on the floor below, which process a binload at a time. After the phosphate is dissolved, the mixture enters a feed tank. At peak loads, both mixing tanks and tilts can be operative.

Economy of Operation

Under the plant are eight rapid mixing basins that incorporate the phosphate mix, lime, chlorine, and fluoride just prior to the delivery of water to Philadelphia consumers. The water flows from the plant, through a prestressed concrete conduit, to a 50-mil gal clear-water basin, and then directly to the consumers.

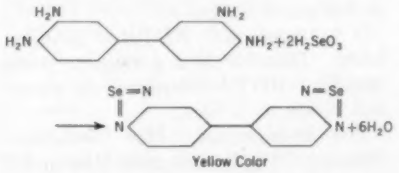
The bulk-handling system in the post-treatment building marks an innovation at Torresdale. The system insures increased operations without extensive labor and handling costs. The old Torresdale plant required 100 employees, plus a sand-washing detail of 15–20 inmates from the city prisons. Now the plant operates with only 75 employees, and the rapid sand filters are washed automatically. There are no personnel assigned specifically to the post-treatment building. The minimal manpower required is supplied, as a supplemental duty, by men working in the filter building.

Suggested Modified Method for Colorimetric Determination of Selenium in Natural Water

George B. Magin Jr., Leland L. Thatcher, Shirley Rettig, and Harry Levine

A contribution to the Journal by George B. Magin Jr., Leland L. Thatcher, Shirley Rettig, and Harry Levine, all Chemists, USGS, Washington, D.C.

METHODS for the determination of selenium have generally been long and involved. Cervenka and Korbova [1] developed a polarographic method for the determination of selenium in water. Deshmukh [2] and his workers developed an iodometric method with the use of thiosulfate. These and other methods depend on selenium concentrations greater than those present in natural waters and generally employ a reduction procedure that is laborious, time-consuming, and relatively insensitive, necessitating the removal or masking of many interfering elements. Hoste,[3] in 1948, reported the use of 3,3'-diaminobenzidine for a qualitative determination of selenium. This determination was based on the fact that the reagent reacts with selenious acid to form an intense yellow piazselenol:



The diaminobenzidine was further studied in 1955 by Hoste and Gillis.[4] They found that Lambert-Beer's law is applicable for concentrations of 0.25–2.5 μg/ml selenium. The reaction is highly specific and the color is stable. Most other ions do not interfere; those that do can be masked. In 1956, Cheng [5] found that at a pH greater than 5, the piazselenol could be quantitatively extracted with toluene, benzene, or xylene, butyl, and amyl alcohols and that ethylenediaminetetraacetic acid tetrasodium salt (EDTA) can be used to minimize the interference of polyvalent metals.

1. General Discussion

Principle. This study is concerned essentially with reproducing Cheng's results and adapting his method to the field of water chemistry. The modified method presented here can be used for 0–50 μg selenium with good results. When the single-extraction technique is used for simplicity, approximately 60 per cent of the selenium is extracted. The results are, therefore, largely empiric, and care must be taken to insure that operating conditions are kept as nearly constant as possible. It is advisable to run a set of standards covering the probable range of concentrations in each series

of unknowns to compensate for variations in operating conditions.

2. Apparatus

2.1. *Separatory funnels,* 250-ml.

2.2. *Ion-exchange columns.**

2.3. *Spectrophotometer.*† Spectrophotometric data are: 420-mμ wavelength; blue phototube; no filter; 40-mm cells; initial sensitivity setting of 3; 0.1-mm slit width; and toluene reference cells.

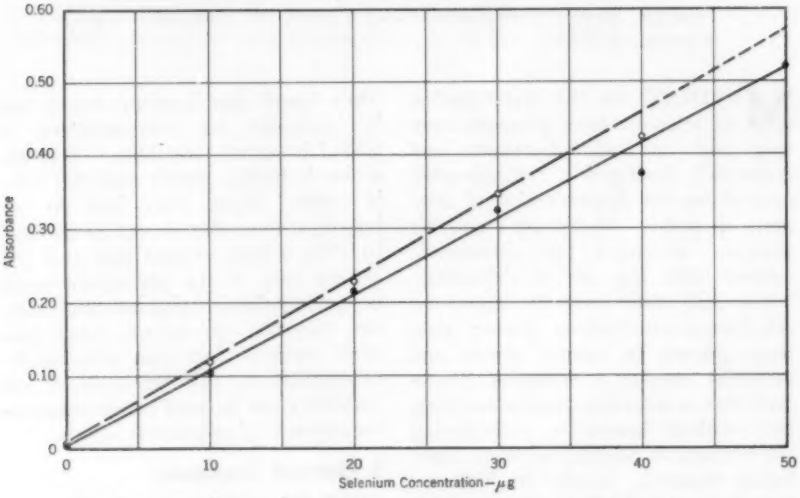


Fig. 1. Typical Curves After Use of Mannitol-3,3′-Diaminobenzidine Hydrochloride Mixture

The curves are from the data shown in Table 2. The solid curve represents Sample A; the dashed curve, Sample B.

3. Reagents

3.1. *Standard selenium solution,* 1.00 ml = 0.010 mg (prepared from pellets of 99.99 per cent Se). Dissolve 1 pellet (approximately 46.1 mg) Se in 5 ml HNO_3, evaporate to dryness, redissolve in a few drops of HNO_3, and dilute to 1 liter. Dilute 216.9 ml of this stock solution to 1 liter. *Caution*: selenium and its compounds are extremely poisonous.

3.2. *Diaminobenzidine solution,* 0.2 per cent. Dissolve 0.40 g reagent grade 3,3′-diaminobenzidine hydrochloride‡ in 200 ml of water.

3.3. *Disodium EDTA solution,* 0.1*M*. Dissolve 37.2 g reagent grade disodium EDTA dihydrate in water, and dilute to 1 liter.

3.4. *Bromthymol blue indicator.* Dissolve 0.1 g bromthymol blue in 3.2

* Amberlite IR-120, made by Rohm & Haas Co., Philadelphia, Pa.

† Beckman Model B, made by Beckman Instruments, Fullerton, Calif.

‡ Baker Catalog No. 8995, of Baker Chemical Co., Phillipsburg, N.J.

TABLE 1

Stability of Diaminobenzidine Hydrochloride in Water With Respect to Time

Date—*1959*	Absorbance With 0.2 mg/l Selenium	Absorbance With Blank
Jan. 20	0.307	0.004
Jan. 22	0.304	0.005
Jan. 23	0.312	0.005

ml 0.05*N* NaOH, and dilute to 250 ml with water.

3.5. *Formic acid, 2.5N.* Mix 28 ml reagent grade HCOOH with 222 ml water.

3.6. *Ammonium hydroxide,* 10 per cent, volume/volume. Dilute 100 ml concentrated NH_4OH to 1 liter with water.

3.7. *Toluene,* spectroanalyzed.

4. Procedure

4.1. Regenerate the ion-exchange columns with 20–30 per cent hydrochloric acid. Flush thoroughly with distilled water. Pour sample through column, discarding the first 20–30 ml of effluent. Collect about 200 ml of sample.

4.2. Measure a volume (150.0 ml maximum) of the effluent containing less than 0.050 mg selenium into a 200-ml volumetric flask.

4.3. Prepare sufficient standard. Toluene is used as the reference solution.

4.4. Add 4 ml 2.5*N* formic acid. The pH should be in the range of 2–3.

4.5. Add 10 ml 0.2 per cent diaminobenzidine hydrochloride, shake for about 30 sec, and let stand 30 min ±1 min.

4.6. Add one drop of bromthymol blue, and titrate with 10 per cent ammonium hydroxide to a blue color. The pH should be in the range of 6–7.

4.7. Dilute to 200 ml, mix, and transfer to a 250-ml separatory funnel.

4.8. Add 25.0 ml toluene and shake for 1 min.

4.9. Let stand until layers are separated. Discard water layer, and pass the toluene layer through No. 40 filter paper to which has been added approximately 100 mg of anhydrous sodium sulfate. Collect in a small beaker.

4.10. Transfer to 40-mm absorption cells, place in spectrophotometer, and measure absorbance of samples and standard.

4.11. Record room temperature.

5. Experimental Results

5.1. The diaminobenzidene reagent is stable in the dry state when kept away from direct light In this form the reagent is white, but when exposed to light, it gradually darkens until a dark purple color forms. Cheng [5] recommended the storing of the aqueous solution in a refrigerator. It was found that refrigeration was effective for at least 3 days, as shown in Table 1, but after that time the reagent began

TABLE 2

Reproducibility of Results With Mannitol-3,3′-Diaminobenzidine Hydrochloride Mixture

Selenium Concentration μg	Absorbance*	
	Sample A	Sample B
10	0.108	0.120
20	0.217	0.230
30	0.322	0.349
40	0.377	0.427
50	0.521	
(20)†	0.228	0.210

* The absorbance of the blanks was 0.005 and 0.010 for Samples A and B, respectively.
† Unknown solution.

to darken. The absorbance of the samples prepared from this solution did not increase.

The reagent can be used in a dry form by mixing one part reagent with twenty parts mannitol and adding the mixture to the samples with a scoop. Data from both methods show fairly close agreement.

5.2. Cheng's method, as modified with the use of the mannitol mixture, gave results that agree with the final composite curve arrived at with the use of the reagent in solution. Table 2 and Fig. 1 show the reproducibility of results when the mannitol-3,3′-diaminobenzidine hydrochloride mixture was used.

5.3. The effect of increasing the amount of 2.5*N* formic acid is shown in Table 3. Amounts of 2–8 ml of acid caused no appreciable change in absorbance when the selenium concentration was 0.15 mg/l.

5.4. The conclusion from the data shown in Table 4 is that no difference in absorbance results from the use of different lots of spectrochemical grade toluene.

5.5. Cheng found that the maximum rate of color development in formic acid occurs at pH 2–3 and that under these conditions color absorbance is at a maximum after 30 min. The data shown in Table 5 do not bear this out, but if the standards and samples are run for 30 min, the results are comparable.

TABLE 3

*Effect of Varying Amounts of 2.5N Formic Acid**

Formic Acid ml	Absorbance
2.0	0.300
2.0	0.285
4.0	0.286
4.0	0.310
6.0	0.315
6.0	0.333
8.0	0.310
8.0	0.311

* The selenium concentration was 0.15 mg/l.

TABLE 4

Effect of Different Lots of Toluene

Toluene Stock Number	Absorbance*
782264	0.342
	0.340
774376	0.325
764017	0.321
	0.338

* Each sample contained 30 μg selenium.

5.6. Cheng studied only the single-extraction procedure, although he recognized that one extraction did not give 100 per cent recovery. He concluded, however, that results were proportioned and reproducible. Data on the effect of double and triple extraction are shown in Table 6. The data indicate that the distribution is nearly constant for one extraction and that there is little advantage in trying to recover 100 per cent of the selenium. The amount extracted in one operation is about 60 per cent. The distribution coefficient will remain fairly constant with careful control of volume, solvent, time, and temperature, but it is recommended that a series of standards be run each time with the unknown.

5.7. Preliminary studies of the effects of ions commonly present in natural waters were made by adding 1 ml of 0.1*M* EDTA to individual samples containing 0.15 mg/l selenium and the following concentrations of ions: 100 and 500 mg/l Na^{+}, 500 mg/l Ca^{++}, 10 mg/l Fe^{++}, 10 mg/l Fe^{+++}, 10 mg/l Cu^{++}, and 10 mg/l Al^{+++}. The addition of EDTA did not prevent interference from 500 mg/l Ca^{++}. When

samples of these concentrations were passed through the ion-exchange column, the interference was minimized. It was therefore concluded that addition of EDTA is satisfactory for samples of very low mineral content, but that deionization is necessary for more highly mineralized samples.

The ion-exchange technique was found to be satisfactory for these concentrations of ions: 10 mg/l Fe^{+++}, 10 mg/l Fe^{++}, 10 mg/l Al^{+++}, 10 mg/l Cu^{++}, 500 mg/l Ca^{++}, 200 mg/l Na^{+}, 125 mg/l HCO_3^{-}, 350 mg/l SO_4^{--}, and 300 mg/l Cl^{-}. The allowable limits may be much higher, although it was found that waters with concentrations of 2,000 mg/l sodium and 3,000 mg/l chloride caused excessive interference, even when diluted 1:5. Greater dilutions would probably cause the relative selenium content to drop below the limits of the method. Table 7 shows the relative interference of 500 mg/l calcium after the solution was treated with EDTA and after it was passed through the ion-exchange column. A series of tests in which natural waters were spiked with 0.20 mg/l selenium showed no influence from the other elements usually present—magnesium, fluoride, and nitrate, for example.

5.8. As previously mentioned, the temperature affects the distribution coefficient. Three different water samples were spiked with varying concentrations of selenium in the range of 0.000–0.333 mg/l, and the temperature of each was recorded during its run (Fig. 2). It is desirable to run a set of standards with each analysis in order to compensate for temperature variation. A composite curve, however, accurate to approximately 5 per cent, can be made for a temperature variation of several degrees (Fig. 3).

TABLE 5

*Effect of Time on Color Development in Acid Solution**

Time *min*	Absorbance
30	0.329
35	0.352
40	0.370
45	0.390

* Temperature, 27°C.

TABLE 6

Effect of Multiple Extractions on Absorbance

Number of Extractions	Selenium Concentration—*mg/l*		
	0.05	0.15	0.25
	Absorbance		
1	0.082	0.248	0.390
2	0.034	0.106	0.168
3	0.015	0.047	0.065
Total	0.131	0.401	0.623
1	0.076	0.242	0.342
2	0.040	0.098	0.146
3	0.025	0.054	0.064
Total	0.141	0.394	0.552

6. Calculations

On standard graph paper, plot concentrations of selenium standards in milligrams per liter against corresponding absorbance readings. Draw a straight line through the plotted points, and determine the selenium concentration of the samples to three decimal places by interpolation from the graph.

7. Precision and Accuracy

The modified method is suitable for the determination of selenium in natural waters in the range of 0–50 μg.

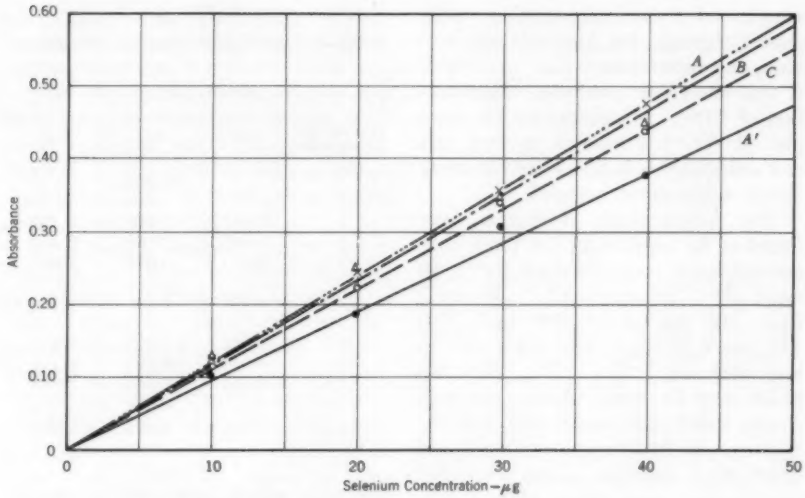


Fig. 2. Effect of Temperature Variation on Absorbance

The letters on the curves designate the samples: A, *at 26.5°C;* B, *at 26.5°C;* C, *at 25.0°C; and* A' (*Sample* A), *at 21.5°C.*

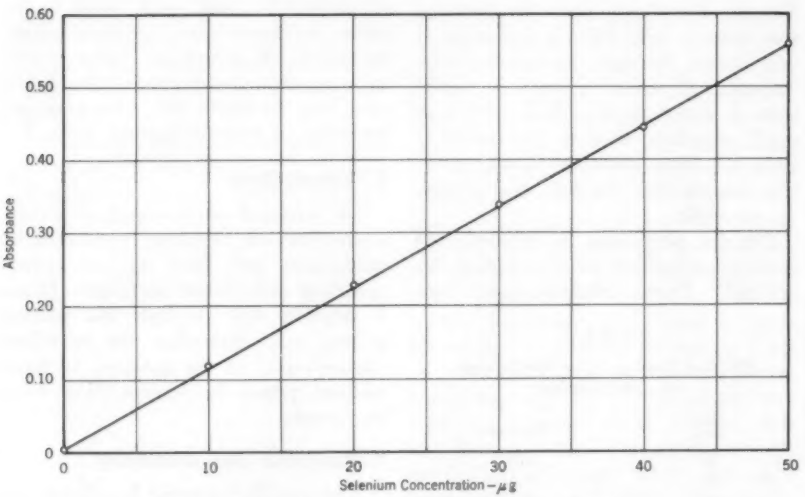


Fig. 3. Composite Curve for Temperature Variation

A composite curve, accurate to approximately 5 per cent, can be made for a temperature variation of several degrees.

TABLE 7

Interference of Calcium

Solution	Absorbance
0.15 mg/l Se	0.339
0.15 mg/l Se plus 500 mg/l Ca (run through ion-exchange column)	0.331
0.15 mg/l Se plus 500 mg/l Ca (1 ml 0.1*M* EDTA added)	0.111

The method is sensitive to 1 μg, and the precision is ± 1 μg. Selenium in brines, however, cannot be determined satisfactorily. Even with a 1:5 dilution of the brines, their dissolved salts interfere, so that accurate results cannot be obtained.

8. Conclusions

The removal of water from the toluene layer can be accomplished by filtering through 100 mg anhydrous sodium sulfate on No. 40 filter paper. This method is quicker than the centrifuging recommended by Cheng, and a comparison of both methods shows no difference. The diaminobenzidine reagent can be added either in the solid form or as a solution. It is easier to use the reagent in solution, provided only enough is made up for a few days at a time.

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Performance Records of Radial Collector Wells in the Ohio River Valley

H. K. Gidley and John H. Millar

A paper presented on Mar. 24, 1960, at the West Virginia Section Meeting, Huntington, W.Va., by H. K. Gidley, Partner, Kelley, Gidley & Staub, Charleston, W.Va., and John H. Millar, Director, Div. of San. Eng., State Health Dept., Charleston, W.Va.

A REPORT on the installation and performance of radial collector wells in Ohio River gravels was published in 1952.[1] The report covered thirteen wells located in West Virginia. In view of the continued industrial expansion in the Ohio River Valley and the installation of additional collector wells along the river, this report has been prepared to include the wells installed since 1952 and bring information on the performance of the collector wells previously described up to date.

Survey of Well Owners

A questionnaire was prepared and sent by the West Virginia Department of Health to all industrial firms and the one municipality in West Virginia known to have a radial collector well or wells in operation. Unusual interest in the subject was demonstrated by all who were surveyed; every questionnaire was returned, and, in all cases, the data had been prepared by high level management and technical personnel.

At present there are 18 radial collector wells in operation in West Virginia. Six wells installed at the West Virginia Ordnance Works in 1942 were removed from service in 1945. Eleven of the wells now operating have been installed since 1952. Well field locations are shown in Fig. 1.

Production Capacities

Of the eleven wells most recently installed, eight had initial capacities varying from 3.7 mgd to 4.3 mgd. Three wells at one location had initial yields of 2.0 mgd, 1.2 mgd, and 1.7 mgd.

Pertinent data on the individual wells are summarized in Table 1. The data include the newer installations as well as the earlier wells. Three of the wells—namely, Parkersburg Water Works Wells No. 4 and 5 and Well No. 3 operated by Calco Chemical Division, American Cyanamid Co.—are located on islands in the river, whereas all other wells are located on the shore near the river's edge. All of the island wells recorded initial productions in excess of 4 mgd.

According to the information submitted by well owners, the safe yield of the collector wells may be somewhat less than the reported initial yields. One can usually expect a decline in well yield with time.

The yield of the well maintained by E. I. du Pont de Nemours & Co. has declined 50 per cent in 12 years. The

three Calco wells show a loss of 30–40 per cent of their initial capacity in 8–12 years.

Solvay Process Division, Allied Chemical Corporation, reports a total output of 6,000 gpm for four wells, or an average of 1,500 gpm per well. The reported initial yield per well was 2,600 gpm. The decline in well capacity, coupled with a water of undesirable mineral characteristics, has led this plant to a decision to install cooling towers to meet cooling-water requirements.

Mineral Content

Table 2 gives partial mineral analysis of waters extracted by radial collector wells from the Ohio River gravel formations. Solvay Process Division Wells No. 1 and 2 have a high chloride and hardness content. This is said to be caused by seepage from a nearby waste disposal bed, and the high chloride content was not present when the wells were installed.

Manganese continues to be a problem at the Parkersburg wells. Excessive manganese appears in four of the five wells. Iron and manganese removal facilities consisting of aeration, chemical treatment, flocculation, sedimentation, and filtration are used to treat the well water for use in the public system. It was originally anticipated that the manganese content of the wells would decrease substantially with continued pumping, but this has not occurred during the first 11 years of operation.

Redevelopment and Maintenance

Because loss of well capacity has been substantial in some instances, well owners were asked whether any maintenance, extension, or redevelopment of collector lines had been required. The following information was received in response to the question:

Solway Process Division Wells. Following a flood in the Ohio River in early spring of 1959, total well output (4 wells) increased from 5,000 gpm to 8,500 gpm. This was attributed to a higher rate of aquifer recharge because of greater head on the aquifer and the scouring of silt from

Fig. 1. Locations of Radial Collector Wells in West Virginia

Numbers of wells and installation dates for all of the locations shown are given in Table 1.

the river bed. Resilting of the bed is considered to be the cause of a gradual deecline of well output from the 1959 high of 8,500 gpm to the present 6,000 gpm.

Parkersburg Water Works Wells. Parkersburg plans to plug present collector lines in No. 2 and No. 3 wells and install new collector lines beneath the river. It is hoped that it will be possible to secure water with lower manganese content.

Silicone Division Wells. One additional lateral has been extended from South Well 200 ft beneath the river. Additional laterals totaling 500 ft have been extended from North Well.

Calco Wells. A program of revitalizing wells is now under consideration.

duPont Well. A decline in well output, believed to be caused by silting of river bottom, is reported.

Navigation Dams

The Army Corps of Engineers has entered into a long-range construction

TABLE 1

Summary of Data on Collector Wells in West Virginia

Well	Year Installed	Depth Below Surface* *ft*	Static Water Depth *ft*	Collector Lines Total Length *ft*	Initial Yield *mgd*	Yield 1960 *mgd*
Solvay Process Div.						
Well No. 1	1954	60	15	756	3.7	8.7
Well No. 2	1952	60	15	800	3.7	
Well No. 3	1952	60	15	802	3.7	
Well No. 4	1954	60	15	756	3.7	
Parkersburg						
Well No. 4	1954	52	26	500	4.0	4.0
Well No. 5	1959	48	26	500	4.2	4.2
National Aniline						
Well No. 1	1953	73	15	800	4.3	
Silicones Div.						
South Well	1954	49	29	792	2.0	2.0
North Well	1954	50	24	1,046	1.2	1.1
Center Well	1957	46	24	400	1.7	1.4
Mobay Chemical Co.						
Well No. 1	1955	51		850	2.3	2.3
Wells Previously Reported						
W.Va. Ordnance Works						
Well No. 1	1942	73	35	804	2.5	
Well No. 2	1942	66	36	899	2.8	
Well No. 3	1942	61	34	1,081	2.2	
Well No. 4	1942	62	33	1,007	1.8	
Well No. 5	1942	59	31	1,001	2.1	
Well No. 6	1942	59	33	1,219	2.1	
Du Pont						
Well No. 1	1947	92	30	1,259	4.5+	2.25
Parkersburg						
Well No. 1	1946	60	16	800	3.5	
Well No. 2	1949	56	17	800	2.5	1.5
Well No. 3	1949	54	18	800	4.0	3.0
Calco						
Well No. 1	1947	36	24	1,008	4.0	2.3
Well No. 2	1948	51	25	1,052	1.7	1.2
Well No. 3	1952	54	31	787	4.6	2.7

program for the improvement of navigation on the Ohio River. Numerous low dams are being replaced by fewer high dams, and normal pool levels are being raised for long stretches of the river. The increase in the normal levels of pools will increase the yield of wells located adjacent to them. For example, the proposed Bellville Dam will raise the normal pool elevation at Parkersburg 12.8 ft. The normal output of the Parkersburg wells should be materially increased by this change in

2. The 24 wells which have been installed in West Virgina indicate that an initial yield of 1.5–4.5 mgd can be expected from a well when the river is at pool stage. Reasonably accurate predictions of initial well yield at specific locations can be determined in advance by hydrologic studies. Considerable local variation in an aquifer is not unusual, and each well must be considered as an individual unit.

3. The initial yield of most radial wells is not sustained with continued

TABLE 2

Mineral Characteristics of Water From Radial Collector Wells

Characteristic	Well									
	Solvay Process				Parkersburg		Silicone Div.			Mobay
	No. 1	No. 2	No. 3	No. 4	No. 4	No. 5	South	North	Center	No. 1
Alkalinity ($CaCO_3$)—*ppm*	100	100	100	80	80	80	84	44	22	75
Hardness ($CaCo_3$)—*ppm*	656	424	256	204	200	200	196	190	188	172
Chloride (Cl)—*ppm*	312*	580*	93	70	28	3	40	36	32	48
Sulfate (SO_4)—*ppm*							96	80	92	70
Calcium (Ca)—*ppm*	262	170	102	70			156	154	156	54
Magnesium (Mg)—*ppm*							40	36	32	9
Silica (SiO_2)—*ppm*							10	7	9	
Iron (Fe)—*ppm*	0.2	0.2	0.2	0.3	0.4	0.3	0.1	0.1	0.3	0.2
Manganese (Mn)—*ppm*	0.3	0.3	0.3	0.3	2.0	0.9				0.9
pH	6.9	6.7	7.0	7.3	7.5	7.3	7.4	6.9	7.1	6.6

* Seepage from waste disposal area.

the river level. Unfortunately, the dam construction program moves slowly; and it will be many years before installation of all of the proposed dams has been completed.

Summary

1. Radial collector wells have been successfully used for the extraction of water from the unconsolidated alluvial deposits which occur in the Ohio River Valley in West Virginia.

pumping, and the decline in production may be as much as 30–50 per cent in a 6–12-yr period. Silting of the river bottom and a resultant lowering of the aquifer recharge rate have been suggested by some as possible causes of the decline in yield. Restoration of well capacity has thus far not been attempted at the locations covered in this report.

4. Water obtained from collector wells is clear, has excellent bacterial

quality, is free of taste and odor, and has a fairly uniform temperature.

5. Water from a well receiving most of its recharge by direct river infiltration has an average hardness comparable to that of the river. In some locations the chemical makeup of the water is materially influenced by the ground water in the vicinity. If objectionable amounts of iron or manganese are normally found in the aquifer at the well location, the presence of the iron or manganese in the well may persist for many years. In addition, the use of waste ponds at industrial plants may result in pollution of the aquifer and a deterioration of water quality.

Acknowledgment

The authors are indebted to all those who furnished the well construction and performance data used in preparing this article.

Reference

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Survey of Ground Water Contamination and Waste Disposal Practices

Task Group Report

A report of Task Group 2450 R—Underground Waste Disposal and Control, presented on May 17, 1960, at the Annual Conference, Bal Harbour, Fla., by Lynn M. Miller (chairman), Jones, Henry & Williams, Cons. Engrs., Toledo, Ohio. Other members of the task group are J. G. Ferris, A. G. Fiedler, G. E. Glover, C. E. Carl, W. N. Gahr, E. F. Gloyna, R. R. Kountz, G. W. Moore, and H. R. Wilke.

IN an effort to expand the vision of Task Group 2450 R, and to provide it with a means of collecting information on ground water contamination from all areas of the country, a questionnaire survey was started in 1952. Repeat surveys of all states were made in 1955, 1957, and 1960. The compiled results up to 1957 were presented in a report published in the JOURNAL in 1957.[1]

1960 Survey

The information presented here was collected primarily from replies to the 1960 questionnaire and supplemental information furnished or brought to the attention of the task group by those who responded. Table 1 is an abbreviated account of the replies. A specific request was made for information concerning incidents observed during 1957, 1958, and 1959.

Of the 48 states that returned the questionnaire, 9 indicated no reported or observed contamination problems; 26 states indicated contamination by sewage; 22 reported oil and gas production waste or petroleum products contaminations; 15 indicated other industrial waste or chemical contaminants; and 13 reported problems which developed from contaminants of another nature.

The actual sources of contamination are seldom unique and most of them were named by several states. The breakdown is as follows: disposal wells, 10; impoundments and lagoons, 19; surface water dumping, 5; septic tanks or cesspools, 18; ground surface dumping, 12; leaking storage tanks or pipelines, 6; accidental spills, 2; and leaking of chlorides from stockpiles, 2. Several states implied or indicated contamination from natural or known sources of unpotable water through poorly or improperly constructed wells.

The frequency of contamination is alarming when it is recalled that these figures cover only a 3-year period. It is more alarming to note that 40 of the state reporters indicated that adequate statutory controls do exist in their states; only two indicated that controls are nonexistent and are not being formulated. Some explanation is offered by the fact that eight states either enacted new legislation or strengthened existing statutes during the 3-year period.

To give the reader a better picture of the types and seriousness of ground

TABLE 1

State	Type of Contaminants					Actual Contaminants
	Sewage	Oil, Gas	Chemical, Industrial	Other	None	
Alabama					x	
Alaska		x				diesel fuel
Arizona					x	
Arkansas		x				salt water
California*		x	x	x		sulfides, saltwater, detergents in sewage, oil field brine, refinery wastes
Colorado			x			
Connecticut	x	x	x			detergents, gasoline, chromium
Delaware†						
Florida	x					sewage, detergents
Georgia	x	x				septic tank effluents, refined gasoline and oil
Hawaii					x	
Idaho	x	x				coliform organisms, petroleum products
Illinois		x	x			brine, heavy metals, dyanide, petrochemical petroleum
Indiana		x	x			chrome wastes, brines, gasoline, fuel oil, pyradine, picoline
Iowa	x					sewage
Kansas	x		x			chlorides from chemical plant, oil field brines
Kentucky		x	x			fluorides, concentrated brine
Louisiana				x		oil field brines or sea water
Maine	x			x		sewage, chlorides
Maryland	x	x		x		gasoline, oil, sewage
Massachusetts	x		x	x		chloride compounds, sewage, phenols
Michigan	x	x	x			detergents, gasoline, dry-cleaning fluid, chromium, disease-producing organisms
Minnesota	x			x		gasoline, sewage
Mississippi					x	
Missouri	x	x				oil, sewage
Montana		x				gasoline
Nebraska	x					detergents
Nevada	x		x			
New Hampshire					x	
New Jersey				x		detergents
New Mexico		x	x	x		oil brines, chemical, industrial contaminants, uranium
New York	x	x	x			sewage, detergents, nitrate
North Carolina	x	x		x		gasoline, fuel oil, sewage, surface water, vermin
North Dakota	x					sewage
Ohio					x	
Oklahoma		x				sodium chloride
Oregon	x			x		turbidity, barnyard drainage
Pennsylvania	x	x	x			
Rhode Island	x			x		sewage, chlorides
South Carolina	x					sewage
South Dakota	x	x		x		turbidity, sewage, petroleum products, chlorides
Tennessee					x	
Texas		x				oil field brine
Utah					x	
Vermont	x					sewage
Virginia					x	
Washington	x			x		salt water, sewage
West Virginia	x	x	x			sewage, brine, dye wastes
Wisconsin†						
Wyoming	x	x	x			sewage, syndets, petroleum fractions, organic industrial wastes

* Totaled response from 8 regions.
† No reply.

Response to Task Group Questionaire, 1960

Source of Contamination						Statutory Control			
Disposal Wells	Impoundments, Lagoons	Surface Water Dumping	Cesspools, Septic Tanks	Ground Surface	Other	Adequate	Non-existent	Being Formulated	Year Enacted
						x			
					leakage of storage tank	x			1949
x	x			x		x			1953
	x			x	improperly constructed wells	x			1959
						x			1949
	x								
	x		x			x			1953
									1959‖
x	x					x			
			x		accidental spills				
x			x			x			1939
	x	x			pipeline leakage or break	x			1955
x	x				ditches	x			1951
									1957
	x				unknown sewage source	x			
x	x				possibly from disposal wells	x			1957
					surface stream drainage into sinkhole	x			
						x			
x			x	x	highway salt piles	x			
		x	x		underground storage tanks	x			1950
	x			x					
			x	x	leaking storage tank	x		x	
			x		accidental spill			x	
						x			1925
			x			x‡	x§		
					leakage of gasoline storage tanks			x	1955
	x	x				x			1957
	x		x	x		x			1952
			x				x		
x	x					x			1899
						x			
	x		x	x					
			x			x			1949
					leakage of gasoline and fuel oil tanks	x			1951
			x				x		
						x			1951
	x			x		x			1956
	x					x			
x			x			x			1937
			x	-	chloride stockpile			x	
x					stream containing sewage	x			
			x	x		x			1955
									1959
						x			1945
	x	x							1955
				x		x			
			x						1953
						x			
	x					x			
x	x	x			unknown salt water source	x			1953
						x			1959
			x	x					
						x			1957

‡ For water pollution, 1957.
§ For construction of wells and septic tanks for private use.
‖ Code isolates water wells from sewage systems; general authority granted to health department.

water contamination reported, the experiences of a few representative states are summarized below.

Michigan

Reports from the Michigan Department of Health include accounts of two instances of serious ground water contamination in 1959.

Excessive quantities of hexavalent chromium were found in two private wells in Tecumseh during July 1959. The chromium was traced to a small machine shop which was occasionally using a chromium compound for cleaning. The waste material is now discharged into the city sewers, but previously a disposal pit on the ground surface was used. The chromium leached from the pit into the ground water strata tapped by the private wells.

During July 1959, a team of public health workers converged on the village of Posen (population 350) to determine the cause of an unusually high incidence of infectious hepatitis. At the time the study began, 84 cases of hepatitis had been reported, and the number increased to 110 during the search. Undoubtedly, there were several subclinical cases that never reached the attention of a physician.

To help in this study 74 private wells were inspected and samples collected. More than 40 per cent of the samples showed evidence of dangerous contamination. The wells ranged in depth from 30 to 135 ft. The area has outcroppings of limestone with 1–20 ft of topsoil. The major causes of contamination appeared to be inadequate isolation from sources of sewage and improper well construction. Most of the homes used septic tanks with leaching pits for disposal of the effluent. In order to install many of the tanks and the pits in the ground, it was necessary to blast into the rock.

Owing to a heavy snowfall and a rather sudden thaw, drainage conditions in Posen were very poor in the water of 1958–59. It is believed that flooding of a particular leaching pit induced the flow of contaminated ground water to other areas. The epidemiological evidence shows that the contamination traveled from house to house, north to south, along the main street.

Massachusetts

During 1959 permission was given by local authorities to operate a circus near a gravel-packed well used as a source of public water supply. The State Department of Health recommended that permission be refused to operate the circus, but the local authorities ignored the recommendation. Examination of conditions during the circus disclosed pollution of the ground by human and animal wastes within 250 ft of the well. Analyses of the water showed the presence of a larger amount of fresh ammonia in the water than is expected in an unpolluted ground water supply. Slight bacterial contamination was also noted. As a result of this incident, legislation has been introduced giving the State Department of Health, in the absence of specific rules and regulations, authority to issue orders only in the event that rules and regulations adopted for the protection of a particular supply have been violated. The department may also withdraw approval of a source of supply if pollution occurs.

The disposal of waste liquor from the manufacture of insecticides into a sump area resulted in phenol pollution of a gravel-packed well located about 500 ft away. Corrective measures

have been taken to prevent the phenol wastes from being discharged near the well, and continual policing will be necessary to prevent a recurrence. The phenol odor still remains in the water of the well and means to correct this condition are being studied.

Dumping of snow containing chloride compounds over an embankment caused a large increase in the chloride content of the water in a gravel-packed well. Drainage was such that water containing the chloride compound ponded in the vicinity of the well. This condition was corrected by providing proper drainage and requesting highway authorities to refrain from dumping snow containing chloride compounds on the embankment near the well.

New Mexico

The issue on recharge of ground waters is a particularly sensitive one in New Mexico, because of the shortage of water in this semiarid part of the country. Dropping ground water tables and encroachment of salt water barriers on domestic and irrigation water supplies have accentuated this situation. At least four problems have arisen during the past year in regard to the use of deep wells for recharge of ground waters with surface runoff or flood waters. So far the state has been successful in controlling the situation, but it is definitely becoming more acute.

It has been the policy to prevent creation of pollution problems prior to the installation of a new industry or project. An example of this was the installation of a new fertilizer plant involving the discharge wastes of high fluoride content. The original design called for leaching these wastes into the sandy soil near the plant, which is directly above the ground water table for an extensive area, with no impervious material for protection. By means of waste treatment and recirculation of waste water, pollution of ground water was avoided.

The installation of six uranium ore mills in New Mexico and one mill in an adjacent state has created both chemical- and radioactive-waste problems. Investigations and control measures in relation to these mills are currently underway. One of the original mills was involved in contamination of a large ground water basin with nitrate waste waters. Elimination of this situation involved a change in process that cost over $500,000, and the problem of proper waste disposal is still not solved.

Pollution control in New Mexico is a cooperative effort between several state agencies, including the Office of the State Engineer, Oil Conservation Commission, Interstate Stream Commission, Game and Fish Department, the Plumbing Administration Board, and Department of Public Health. The latter has been designated by the governor as the official water pollution control agency.

Missouri

Two types of ground water contamination have been experienced in Missouri, one source from oil and gas wastes and the other from domestic sewage. All of the incidents of contamination have occurred in privately owned wells or semipublic supplies, such as those of private camps of organized groups. In no instance have wells used as sources of public supplies experienced direct contamination. This does not mean that all of the public ground water sources are free from some bacterial contamination; some

wells in limestone formations show periodic bacterial contamination.

Contamination of wells by either oil wastes or domestic sewage occurs quite frequently in private wells of small communities or wells on farms. This is attributed to the fact that privately owned wells are rarely properly constructed, particularly in regard to casing depth. The construction of all wells for public supply is approved by the State Division of Health, and the depth of the casing is determined by the state geologist, based on examination of drill cuttings submitted and examined during the drilling of the well. In many instances, contamination of private well supplies goes undetected. Investigations indicate that the presence of oil in a well is usually due to faulty construction. Perhaps the most serious ground water contamination that occurred in Missouri was Monark Springs epidemic. This contamination was due to faulty construction and proximity of the septic tank and well.

There is now statutory control of pollution of underground sources and surface supplies such as lakes and streams. The law, however, does not provide for control of waste disposal on the ground surface unless the waste eventually reaches a lake or stream within the state. There is no statutory control over the drilling of a private well or construction of sewage facilities on private property.

Virginia

No instance of ground water contamination from liquid waste disposal practices has been reported in Virginia. It is realized that such contamination has occurred, particularly from underground disposal of synthetic detergents, in other states. The problem could occur in Virginia at almost any time because there is considerable underground disposal of household wastes and sewage.

Minnesota

Frank J. Kilpatrick, assistant director of the Division of Environmental Sanitation, Minnesota State Department of Health, has continued his 1959 work reported in *Minnesota Municipalities.*[2] Some of the findings are discussed below:

During April 1959, the Minnesota Department of Health, in a routine survey of a private water supply suspected of contributing to family illness, found surfactant and nitrates in unusually high concentrations for the area.

This discovery led to a series of comprehensive surveys designed to disclose the extent to which the ground waters, and consequently the individual water supplies, of the Minneapolis–St. Paul area are affected by recirculation of sewage from individual sewerage systems. Surveys have been completed in 29 communities involving about 54,000 private water supplies, and seven more are underway or planned. The findings so far have been startling.

Each survey has consisted of the collection of water from a number of representative water supplies selected at random throughout the community. The samples are examined for chemicals and bacteria of sewage origin. The findings show that the ground water beneath the communities involved are currently so affected by recirculation that approximately 50 per cent (27,000) of the households can no longer be secure in the use of their water supplies for drinking and culinary purposes.

The concentrations of surfactants and of nitrates indicated that there had been fractional to complete recirculation. In some extreme cases the water appears to have been through sewerage systems more than once. In others, the contamination has advanced so far that bacteria of sewage origin (coliform organisms) are found. About 11 per cent of the water supplies tested contained nitrate nitrogen in concentration of more than 10 ppm and are therefore unsafe for use in the preparation of infant formulas.

New York

Contamination of some of New York's ground water has been caused by the discharge of sewage through septic tanks to tile fields and cesspools. This is particularly true in Suffolk and Nassau counties, where this problem is under study. The study has been expanded to a limited extent in upstate areas, where contamination of shallow private ground water wells by sewage wastes, particularly detergents, has been found.

A recent complaint was one concerning contamination of private ground water supplies by chemical and industrial wastes. Equipment to prevent air pollution was installed at a plant manufacturing fertilizer. The wastes were lagooned, and high nitrate concentrations subsequently appeared in private well supplies in the vicinity of the lagoon.

One 1959 instance of pollution of private wells in a subdivision was traced to septic tanks and tile fields installed in limited soil cover above limestone. It was necessary for a public water system to be installed, as every effort to eliminate or reduce the pollution of private water supplies failed, even when wells were cased to the bottom and redrilled.

Recently a small public spring supply was found to be contaminated by industrial detergents. The detergent was not anionic and the local public health engineer was not able to trace the source. A manufacturing company was disposing of a small volume of concentrated wastes by spraying them in a gravel bed, located 1,500–1,800 ft from the spring. The practice was discontinued, and since then the physical quality of the water from this spring supply has improved.

Rhode Island

Jerome Deluty has reported in an article[8] concerning well water in Rhode Island.

The Rhode Island Department of Health has found synthetic detergents in samples from 72 wells in various localities in the state since January 1959. The detergents were first evidenced by the formation of a soapy foam in the bottle upon shaking, and their presence was confirmed by laboratory analysis. The presence of syndets in the wells was believed to have resulted from leaching through the ground into the ground water. Unlike soaps, which are precipitated by the calcium and magnesium in the water and left behind, synthetic detergents are only partly removed by a septic tank and absorption field. They are very stable chemicals and travel appreciable distances through the ground into the water table and move with it.

In certain areas, detergent contamination has been found to extend into almost all of the wells. One such area is the Quaker Hill subdivision in Portsmouth, which consists of about 50 homes with no public sewers and no public water supply. This subdivision

was developed during the period 1953–58. The house lots vary in size from 7,000–15,000 sq ft, the average lot being approximately 8,850 sq ft. Individual wells are drilled through the overburden into Pennsylvania sandstone, shales, and conglomerates. Water is furnished through openings along bedding plains and openings in the zone of fractures. The homes have septic tanks and absorption fields for sewage and waste disposal, but as the lots are fairly small, most of the wells are within 75 ft of the disposal unit.

A total of 25 wells in this area were analyzed, and all but one contained detergents. The amount ranged from 0.15 to 5.0 ppm. When shaken, most of the samples showed a soapy foam, but several did not. The detergent level of those that did not appear soapy was in the range 0.15–0.4 ppm. Generally, a syndet concentration of at least 0.5–0.6 ppm is necessary to cause a soapy foam; the higher the concentration, the more abundant and persistent the foam. Some of the wells exhibiting high concentrations of syndets were as much as 300 ft deep.

Only six of the 25 wells showed any laboratory evidence of bacteriologic contamination, and few exhibited high nitrogen values. The only form of nitrogen that tended to be abnormally high for this area was the nitrate nitrogen. Many of the wells in this subdivision would be considered safe on the basis solely of routine bacteriologic and chemical examinations.

Reports from many states indicate conditions similar to those given above and some may be even more dramatic. The point has been made, however, that while it appears much is being done to educate the public and to provide adequate statutory controls, practices of waste disposal which jeopardize the health of the public are allowed to continue.

Synthetic Detergents

The task group has for some time been interested in finding some trace constituents which could be used for early determinations of ground water contamination. It would seem that the efforts might be discontinued for domestic sewage detection, as synthetic detergents (syndets) produce foaming at less than 1 ppm and are detectable at much lower concentrations through chemical analyses.

The Federal Housing Administration has in at least one case chosen to use syndets as an indicator of pollution.[4] In the Minneapolis–St. Paul area of Minnesota very stringent regulations have been adopted by FHA for the protection of public health. These regulations primarily concern the isolation and construction of private water wells and set quality limits for the water produced.

Well Regulations

Future developments may be curtailed to some extent if a satisfactory means of waste disposal for suburban housing is not developed. In some cases it may be more practical to develop a public water supply system. This is not meant to imply that public water supply wells may be magically immune to contamination. But, the isolation and construction of public water supply wells are guarded by statute and regulations which provide the greatest possible security.

It is readily acknowledged that not all suburban developments can be provided with either a public water supply or sewerage system. In some areas it is not even the best use of water resources to attempt such systems.

Therefore, it appears obvious that there is a considerable need for regulation of water well construction practices that will be applicable to all wells supplying water for human consumption. The state of Wisconsin has the most stringent regulations to date, but a few other states have what appear to be satisfactory regulations of a similar nature. The greatest problem with such statutes lies in their policing and enforcement.

Future Problems

A recent survey [5] indicated that 33 states permit the use of ponds or lagoons for the oxidation or stabilization of municipal sewage. The replies to the task group's questionnaire indicated that nineteen states have experienced ground water contamination from similar sources. Furthermore, several of the states permitting these lagoons are those that have had the contamination experiences. Nebraska has reported contamination of an irrigation well, several private wells, and power company wells in the vicinity of such an installation. The lagoon was an experimental unit and was abandoned when problems developed, but no action has been taken to clear the wells. The report indicated that they do not know what to do. It is quite probable that many more such incidents will occur as the use of such lagoons becomes more widespread.

Conclusion

Although many states are exhibiting a growing interest in the elimination of undesirable waste disposal practices, the interest is not great enough in view of the continuing practices which are hazardous to private and public water supplies. The frequency of syndet detection in private water supplies has indicated a need for closer regulation of waste disposal practices and the location and construction of water wells. Public health agencies and the water supply industry must remain vigilant and aggressive in pursuance of their duty to detect and eliminate conditions which may or do lead to contamination of potable supplies.

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Developments in Artificial Ground Water Recharge in the United States

Task Group Report

A report of Task Group 2440 R—Artificial Ground Water Recharge, presented on May 17, 1960, at the Annual Conference, Bal Harbour, Fla., by John J. Baffa (Chairman), Cons. Engr., New York, N.Y. Other members of the task group are H. C. Barksdale, C. M. Bechert, M. L. Brashears, C. R. Compton, F. B. Laverty, L. B. Losee, A M Rawn, L. F. Warrick, and W. F. Welsch.

ARTIFICIAL ground water recharge practices in the United States were again the subject of a biennial questionnaire circulated in 1959 by Task Group 2440 R—Artificial Ground Water Recharge. Replies were received from all states and the District of Columbia. Respondents included ground water representatives of USGS, state sanitary engineers, and state water control and conservation agencies. The task group has also studied legislation affecting artificial ground water recharge and all available literature issued since its previous report.[1]

Recent Developments

Answers to the 1959 questionnaire indicated that:

1. Large volumes of water are being used to replenish ground water by artificial means
2. Interest in artificial recharge continues unabated, as evidenced by the initiation of additional experimental projects and inquiry into fundamental principles of recharge
3. Interest has increased in the economics of artificial recharge as a water supply method
4. Interest in operating data for recharge projects has increased.

National Legislation

On Apr. 20, 1959, Senate Resolution 48 was passed by the United States Senate. This resolution authorized the establishment of a special temporary committee to study water resources activities in the United States and to make recommendations to the Senate for use in considering water resources policies for the future. On the agenda of this committee is a water supply-demand study that will consider available ground water supplies as a means of meeting water needs. Also to be included are studies of waste water reclamation. The task group believes that artificial recharge provides an economically advantageous supply method for water catchment, storage, quality control, waste water reclamation, and water resources protection and conservation. On this basis, current artificial recharge practices should be evaluated in the national water resources inventory.

State Legislation

New York. In keeping with the increasing nationwide attention to regional needs for water resources, the Conservation Law of the State of New York was amended by Chapter 843 of the Laws of 1959. The Water

Power and Control Commission was renamed the Water Resources Commission. The commission was expanded to include the commissioner of health and the commissioner of agriculture. The commission was also authorized to make studies of water resources on an areal or regional basis.

California. Artificial recharge practices in California were reported by Harvey O. Banks, director of the Department of Water Resources:

> Studies in 1958 and 1959 showed that 55 public and private agencies operated about 275 artificial recharge projects and planned about 30 additional projects. The figure of 275 compares with a figure of 78 projects evolved from a similar study made in 1955. The water that is spread at the major number of these projects goes into the ground water basins which are common reservoirs for domestic, municipal, industrial, and irrigation supply.
>
> Recorded amounts of recharge in the period 1912–13 through 1957–58 totaled about 6,250,000 acre-ft, of which about 640,000 acre-ft occurred during the 1957–58 water year. In addition, there is a considerable amount of recharge in areas where activity in this field was reported but where no measurements of volume were made.
>
> A study indicated that in inland areas where sewage effluent is disposed of on land, approximately 85 per cent of the water disposed is conserved. . . .
>
> Studies are in progress which consider not only the economic benefits of artificial recharge but also water quality aspects and maximum practicable utilization of local supplies. These studies indicate that in Southern California, such conservation will not remove the necessity for the construction of additional facilities for the importation of water. As a consequence of this conclusion and other economic factors, studies are being made which also consider the use of ground water basins for the regulation of a portion of the supply derived from facilities which import water.

Illinois. A summary of eight full seasons of recharge operations at the Peoria infiltration pits has been reported by Robert H. Harmeson,[2] head of the Peoria Laboratory of the Illinois State Water Survey Division. In eight seasons of operation, 3.58 bil gal of water have been used for recharge. This represents an average recharge of about 4.7 mil gal per operating day. Operating procedures have included measurements of river stage, ground water level, river temperatures, chemical constituents, applied chlorine dosage, silt tests, agar plate counts, and tabulation of confirmed lactose fermentation tubes. The bacterial tests were made to control chlorine dosage. Costs of operation were 2.7 cents per 1,000 gal recharged in 1954–55, 2.9 cents in 1955–56, and 1.6 cents in 1956–58. Recharge operations by the State Water Survey were terminated in May 1959. It has been proposed that the operation be continued by a local corporate body at an estimated cost of 2 cents per 1,000 gal recharged. This includes the salary of a part-time project engineer, wages of pit operators, and costs of water, electricity, gas, pit cleaning, chemicals, and equipment maintenance.

Washington and Oregon. Extensive data on artificial recharge practices in Washington and Oregon have been made available by USGS in a report by D. H. Hart.[3] Nine installations are described in the report. The purposes of recharging are to replenish supply, conserve the physical characteristics of water, or dispose of excess uncontaminated water. In the nine installations, approximately 2,558 acre-ft/yr are recharged. Of this amount, 695 acre-ft are recharged with exhaust water from heat pumps.

The Richland, Wash., public supply system utilizes the largest amount of recharge water—12,000 acre-ft/yr. Of this amount, 2,200 acre-ft are pumped from the Columbia River; the remainder is diverted by a canal from the Yakima River. The Richland system uses recharge ponds; all the other operations use recharge wells. Hart's report states that "the success to date indicates that the process will find greater use in the future." As to the recording of operating data, the report states:

> The operators have found that some operating problems arose from insufficient records of the amounts of water recharged and withdrawn and of the chemical and physical quality of the water. The study indicates that future users of artificial recharge will find it advisable to record such data regularly.

Also in Washington, an evaluation of the water supply recharge experiment in Walla Walla has been prepared and is currently being reviewed by USGS for public release.

Long Island, N.Y.

Fred W. Welsch, the senior hydraulic engineer of the Nassau County Department of Public Works, reports that under a long-range drainage and conservation program, 405 storm water recharge basins have been developed successfully in Nassau County and 400 storm water recharge basins have been developed in Suffolk County. Both counties are located in Long Island. It is estimated that approximately 40 mgd of storm water runoff replenishes ground water storage in Nassau County at the present time. Future development of recharge facilities may ultimately increase this figure to 70 mgd. The corresponding figures for Suffolk County are 10 mgd and 50 mgd, respectively.

Salt Water Intrusion

Reports from Florida state that dams in drainage canals are operated to keep canal levels high during dry periods in order to prevent sea water intrusion in coastal areas. The most noteworthy development since the task group's last report has been in California. The Division of Resources Planning of the California State Department of Water Resources has issued a report on sea water intrusion in California.[4] Appendix B of the report is a statement by the Los Angeles County Flood Control District on "Investigational Work for Prevention and Control of Sea Water Intrusion, West Coast Basin Experimental Projects, Los Angeles County." The report describes and records the extensive field and laboratory experimental activities performed in connection with this large-scale project. The present status of sea water intrusion into coastal ground water basins in California is discussed, methods of control are described, and experimental studies applicable to the determination of design criteria are summarized.

The report presents a great deal of data on well injection rates and hydraulic and chemical gradients in the aquifers tested. It recommends a continuous program of study and legislation for planned utilization of ground water basins, together with positive action to halt and abate sea water intrusion in all basins known to be affected and to prevent intrusion into the threatened areas.

Reclamation of Sewage Effluents

The recharge of ground water by sewage effluents is also receiving attention. The final report of Los Angeles County on the 37-month Hyperion reclamation and recharge test has been prepared. Effluent from the Hyperion

high-rate activated-sludge plant, normally discharged to the ocean, was used as a source of water. Intermittent spreading in small basins four times daily, allowing time for soil reaeration between spreading cycles, was highly effective. The biochemical oxygen demand and the suspended-solids content of the effluent from activated-sludge treatment were reduced by 90–95 per cent and produced a water meeting the USPHS standard for drinking water. Water treated by this method was successfully recharged through an injection well for a continuous period of 6 months. Percolation of the chlorinated reclaimed water through short reaches of aquifer following injection achieved further improvement in the organic and bacteriologic quality of the water. San Bernardino, Calif., plans to recharge its ground water supply with effluent from a sewage treatment plant.

Rawn and Hedger,[5] in a report to the Board of Supervisors of Los Angeles County, envisioned a demonstration plant to provide 10 mgd for recharge of ground water. The Water Pollution Research Laboratory in Great Britain reports large-scale experiments in progress to determine effects of recharging ground water supplies with treated sewage effluents. Ongerth and Harmon[6] have discussed the sanitary engineering aspects of recharge with reclaimed sewage.

New Projects

Milwaukee will participate in an experiment to determine whether the rock formation from which the suburb Wauwatosa, Wis., obtains its supply can be recharged with filtered Lake Michigan water. Studies initiated by state and local officials, as a result of accelerated lowering of the ground water levels because of increased demands during World War II, indicated the practicability and potential benefits of such a program.

Kalamazoo, Mich., in cooperation with USGS, is engaged in an extensive, well planned recharge experiment to study well field recharge by means of a recharge pond. Both the well field and recharge pond are alongside a stream. It is planned to increase natural recharge from the stream by means of a pond and channels. Studies will include the determination of the hydraulic characteristics of aquifers and aquicludes; determination of the amount of recharge under conditions of drawdown and equilibrium of surface water level while wells are pumped; determination of the portion of well discharge that is derived from surface recharge; evaluation of long-term effects of streamflow characteristics; observation of changes in mineral content and temperature; and determination of natural evaporation-transpiration losses and changes in evaporation-transpiration caused by pumping under varying conditions.

Past Studies

A study was recently completed at Newark, Del., on the feasibility of recharging ground water supplies from surface sources.[7] Water table fluctuations induced by intermittent recharge have been analyzed and formulated by Maasland.[8] The theory may be applied to problems of ground water flow through aquifers. The zone of aeration and its relationship to ground water recharge have been discussed in an article on the results of experiments on natural recharge at Seabrook, N.J.[9] Muckel[10] has described recharge methods, selection of recharge sites, and infiltration and percolation experiments in San Joaquin Valley, Calif.

Conclusions

On the basis of data reported in its 1959 questionnaire, the task group concludes that developments in the last 2 years indicate that:

1. Artificial recharge activities comprise an important facet of the national water resource inventory

2. Continuing experiment and research contribute to the ever increasing knowledge of the basic principles governing the artificial recharge of ground water

3. The economic aspects of ground water recharge show that there is available an advantageous method of supplying water where applicable

4. Operating and cost records of recharge operations have proved helpful to operators engaged in recharge operations and to the water supply field in general.

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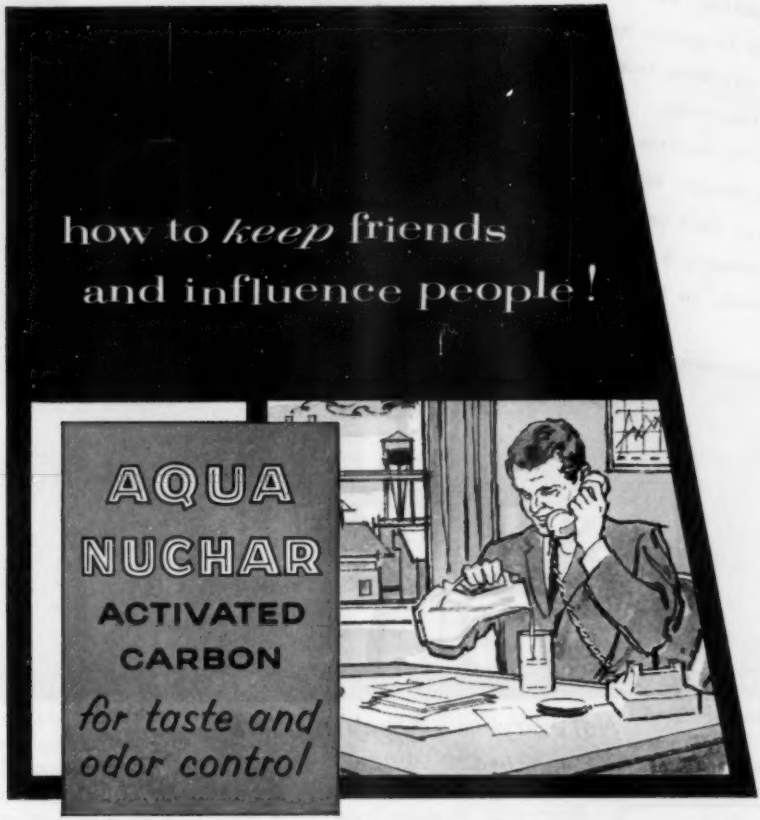

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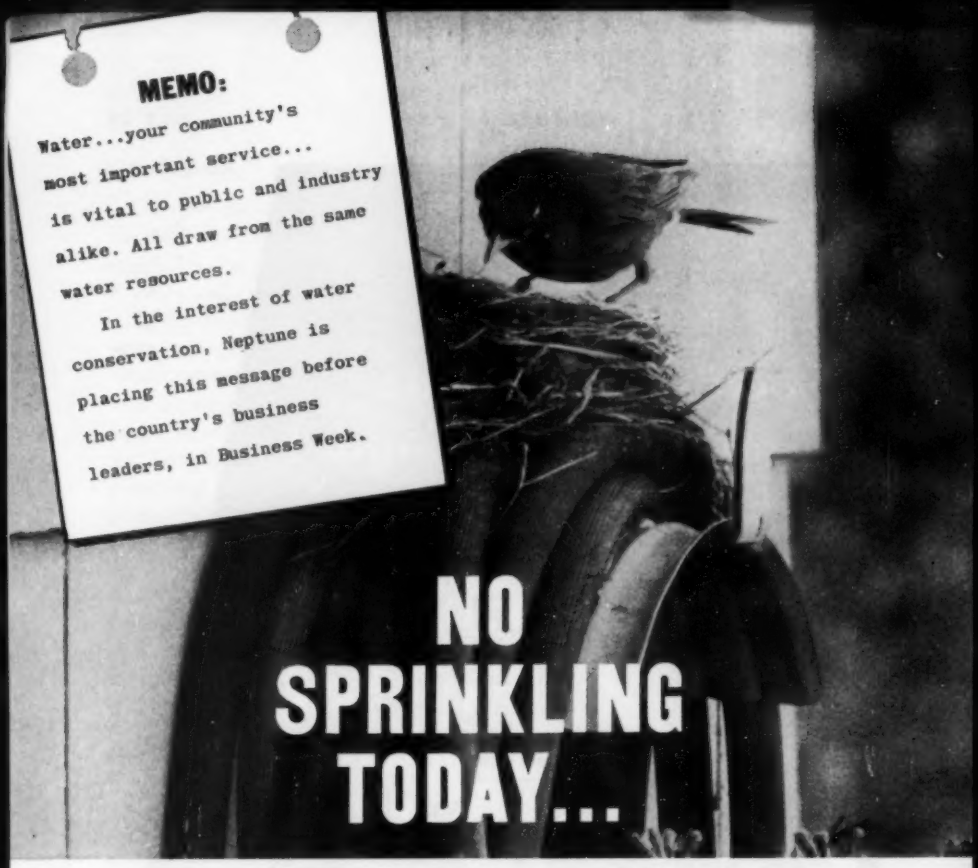
MEMO:
Water...your community's most important service... is vital to public and industry alike. All draw from the same water resources.
In the interest of water conservation, Neptune is placing this message before the country's business leaders, in Business Week.
NO SPRINKLING TODAY...

Not everyone's happy as a lark in the summer*

Every year, in many areas of the country, water wells bottom out, reservoirs bare their skeletons, water pressures drop, and political pressures rise. It's getting worse. In 20 years the country will need twice as much water. New resources will cost billions . . . *if they can be found at all.* It's time to face up to this problem *now.*

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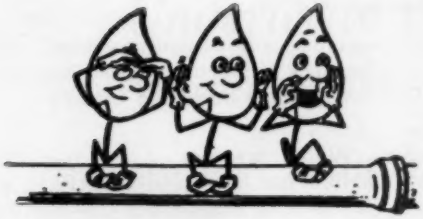


Percolation and Runoff

Summer complaint—characterized by extreme hotness under the water customer's collar at the inadequacies of water service during the hot-weather season—is now epidemic from one end of the country to the other. In Boston it began with record heat in June, in northern New Jersey it blossomed under the hot sun of July, as it did in St. Petersburg, Fla., and Salt Lake City, Utah. And in a thousand other communities from coast to coast the same old summer temperatures are creating the same old high demands, resulting in the same old symptoms of low pressure, and evoking the same old remedy of rationing. As usual, too, almost everywhere there is no drought about it, merely the lack of facilities adequate to deliver enough water to meet maximum demands. In the Boston area, for instance, the "shortages" were experienced when Quabbin Reservoir was overflowing, with 415 bil gal. In St. Petersburg rationing was being enforced despite the fact that the area's annual rainfall of more than 53 in. was being delivered as per schedule. And elsewhere over the nation inadequate transmission facilities, inadequate treatment capacity, inadequate distribution mains, inadequate pumps, and inadequate storage were subjecting millions of customers to their annual siege of water disservice.

Of course, this sad malady is all the customer's own fault for failing to appreciate the necessity for long-range planning and construction, for failing to understand the importance of providing reserve capacity, and for failing to support adequate water rates—assuming, that is (and we should certainly be able so to assume), that the water utility has given the customer full opportunity to appreciate, understand, and support. Where the assumption is not true, where the utility has decided to wait for the customer to educate himself, the summer complaint is likely soon to become more uncomfortable for the utility than it has been for the customer.

Whatever the problems of an individual community, however, there does seem to be some overall hope. Through the local public relations efforts of some forward-looking utilities, through the national advertising of a number of manufacturers supplying the field, through the widening program of the WSWMA-supported National Water Institute, and through AWWA's own Advancement effort, progress toward educating the public is being made.

(Continued on page 36 P&R)

(*Continued from page 35 P&R*)

We were happy to read in the Miami, Fla., *Herald,* for instance, that:

> Basically, St. Petersburg's problem is lack of planning. It simply does not have facilities to handle enough water during a dry spell when residents want to keep their lawns and gardens green.

and, in the Newark, N.J., *News,* that:

> In most parts of the country there is no actual lack of water. There is deficiency principally in storage, transmission, pumping, and treatment capacity. . . . Correcting all these shortcomings, especially by construction of new reservoirs, will take years, and a lot more public interest than is generally shown in the problem. Meanwhile, the municipalities have a responsibility. Many of them have made no effort to keep new construction in balance with existing water supplies. Where shortages have occurred or are approaching, some municipalities may have to consider invoking their zoning power to restrict residential growth and industrial development until supplies can be expanded.

and in the *1960 Policy Declarations* of the US Chamber of Commerce, that:

> State and local governments and private agencies are urged to make long-range plans for development and management of water supplies to relieve present or impending shortages.

And we were no less happy to note that US Senator Philip A. Hart (D., Mich.) was concerned enough about "the grave need of the country to have a good water supply where we need it, when we need it, and in the quality we need" to use the problem as the subject of his weekly TV program, *Washington to Michigan,* last May. Thus, slow by slow, appreciation, understanding, and support are being helped to grow. And the efforts of everyone are earnestly solicited for the work of this unorganized National Foundation for Summer Complaint.

Water pressure of the type described last month (August P&R, p. 42) as being unsuccessfully exerted by Toledo, Ohio, to force annexations, has been successfully applied at Louisville, Ky., in winning for the local water utility the right to charge the cost of extending water mains to the customer, subject to refunds as new services are added to the extended mains. Thus, after banning extensions beyond city limits for 16 months because of a court order forbidding it from passing on the costs of such extensions, the utility resumed providing such service in July under a new public service commission order. Requiring municipal utilities to make extensions in an area within 5 mi of city limits, except where determined unreasonable, the new order permits the utility to file with the commission its own rules concerning payment therefor. And the rules filed by the Louisville Water Co. and approved by the commission re-establish the program in existence before the ban.

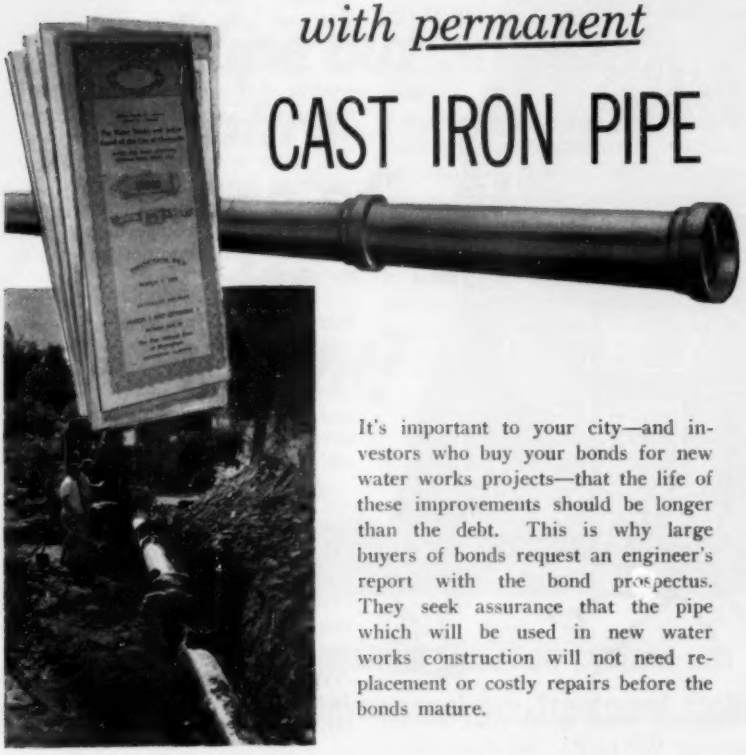
Real estate developers who originally built up the pressure with their suits against the utility were no doubt relieved to have it relieved so they could get back to work again, recognizing that Louisville grows where water flows, even though it can't be free-flowing.

A motto which hangs in the offices of the Stamford Water Co. is, we would say, as clear as A. Bell: "Of course, I need it today. If I wanted it tomorrow, I'd ask for it tomorrow!"

(*Continued on page 38 P&R*)

Underwrite Your Bonds for Water Works Improvements with permanent

CAST IRON PIPE



It's important to your city—and investors who buy your bonds for new water works projects—that the life of these improvements should be longer than the debt. This is why large buyers of bonds request an engineer's report with the bond prospectus. They seek assurance that the pipe which will be used in new water works construction will not need replacement or costly repairs before the bonds mature.

No other pipe has ever matched the trouble-free service record or longevity of Cast Iron Pipe. Sixty-eight North American cities are still using cast iron mains laid a century or more ago. Hundreds more have passed the 50-year mark. When your community extends or improves its water system, specify Cast Iron Pipe, which has long been known as

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This advertisement is published in the interests of the Cast Iron Pressure Pipe Industry by.....

WOODWARD IRON COMPANY

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(*Continued from page 36 P&R*)

Fire Prevention Week, Oct. 9–15, deserves your support not only because the proverbial ounce of prevention can be worth many gallons of the care you must provide, but because, as things now are, a fire breaks out somewhere in the US or Canada every 15 sec and kills a human being every 45 min. Fire Prevention Week can give you a peg on which to hang your fire protection story as well as an opportunity to take the lead in an important community effort. The National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass., has developed a kit of campaign material for your use or you may prefer to do it yourself, letting Willing Water take care of Sparky, NFPA's fire dog.

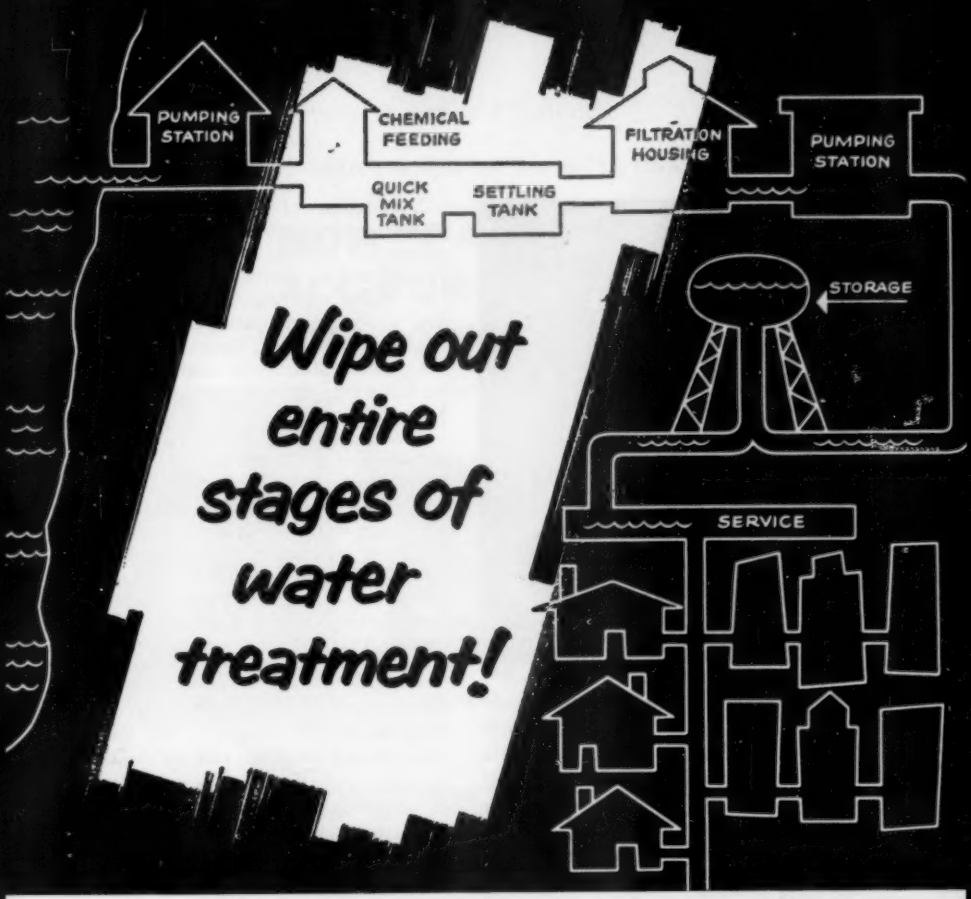
Nuestro tema es el AGUA—our theme is WATER! So says AIDIS (the Inter-American Association of Sanitary Engineering) of its activities for 1960. And WATER will be the theme, also, for the Seventh AIDIS Congress, to be held in Montevideo, Uruguay, on Oct. 2–9. Of its theme our sister society says:

> Never have we sanitary engineers had such a specific challenge as water on a global basis. This presents us not only with an opportunity to demonstrate what we can do for man but also places on our shoulders a tremendous responsibility. There is no other single item which is as important to man and his well-being as water. Just how important is water? You and I and our sanitary engineering colleagues know, . . . but have we gotten our point across? In many areas it is evident that we have not. Everybody agrees that water is a top-priority item. Then it is relegated far down the scale, . . . while it is denied the financing necessary to accomplish the goal. Sadly, it looks as though we sanitary engineers have failed in an important part of our mission. We have not effectively told the story.
>
> That water should be self-supporting, that it can pay its own way, is something which has been proven in many places. It is against this background that we must use our best skills and imaginations and move forward. Some sections have already gotten underway—Panama, Peru, and others. . . .

All of which comes so close to home that we wonder if AWWA, overburdened though it be with present activities and problems, shouldn't be extending its good neighborship to help meet the challenge that AIDIS points out. After all, the first "A" in AWWA is big enough to reach from Pole to Pole and *nuestro tema es el AGUA*, too.

Max Levine, recently retired from the position of chief, Bureau of Laboratories, Hawaii State Department of Health, was awarded an honorary degree of Doctor of Science by the University of Hawaii on Jun. 12, 1960. Prior to his position in Hawaii, he was professor in charge of the Department of Bacteriology at Iowa State University. He has been an AWWA member since 1921.

(*Continued on page 40 P&R*)



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Now you can do something about skyrocketing per capita water consumption costs—as are dozens of municipalities every year. And get clearer, sparkling-bright water in the bargain!

Install one of today's small compact diatomite filtration plants, using Celite* filter aids. In many cases, raw water can be filtered directly, eliminating several of the costly conventional pretreatment stages—flocculation, quick-mixing tanks, and settling tanks, for example.

Result†: Filtration plants requiring only ¼ the space of sand plants of equal capacity. Capital costs cut almost in half—savings of up to 45%.

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* Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

† See *Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956, or write for free reprint.

JOHNS-MANVILLE JM

(*Continued from page 38 P&R*)

M. J. Harper, vice-president, Rockwell Mfg. Co., was awarded a plaque by the metering subcommittee of the American Gas Assn., on May 9, 1960, at the twentieth annual dinner given for the committee by the Rockwell Co. The plaque was presented in recognition of Michael Joseph's "good fellowship and many years of valuable assistance to the metering subcommittee."

The International Water Supply Assn. will hold its Fifth Congress in the new Congress Hall in West Berlin from May 29 to Jun. 3, 1961. Twenty-seven countries are presently members of the association, and 22 more participated in the previous congresses. The work schedule of the Fifth Congress includes a general international report on each of the following seven topics:

1. Water disinfection—eighteen nations participating; US national rapporteur (and general rapporteur), Harry A. Faber.
2. Pollution of surface and underground waters—nineteen nations participating; US national rapporteurs, John W. Cramer and E. Sherman Chase.
3. Water metering and meters—nineteen nations participating; US national rapporteur, James G. Carns.
4. Statistical analysis—eighteen nations participating; US national rapporteur, John C. Geyer.
5. Automation—eighteen nations participating; US national rapporteur, Victor A. Appleyard.
6. Problems of local and regional water supply systems—eighteen nations participating; US national rapporteur, John G. McFarland.
7. Large-diameter pipe—eighteen nations participating; US national rapporteur, H. Arthur Price.

In addition to the general international reports on the seven subjects, the program of the congress will include two plenary sessions, one on desalting of water and the other on radioactivity of water supplies. There will also be a special session on the new program of the World Health Organization for stimulating the development of public water supplies in underdeveloped areas, as well as a meeting of specialists on water treatment and analysis. In conjunction with the congress, an international exhibition of water supply equipment and services will be held.

The headquarters address of the International Water Supply Assn. is 34 Park St., London W.1, England.

Water company inspector, with long black beard, 7 years old (black beard, that is); married (inspector, that is) to woman who refuses to kiss him without black beard (his, that is); two children, aged 4 and 6, who strongly favor retention of black beard; previous experience with Mid-

(*Continued on page 42 P&R*)

POSITIVE CONTROL OF MATERIALS IN MOTION BIF METERS FEEDERS CONTROLS

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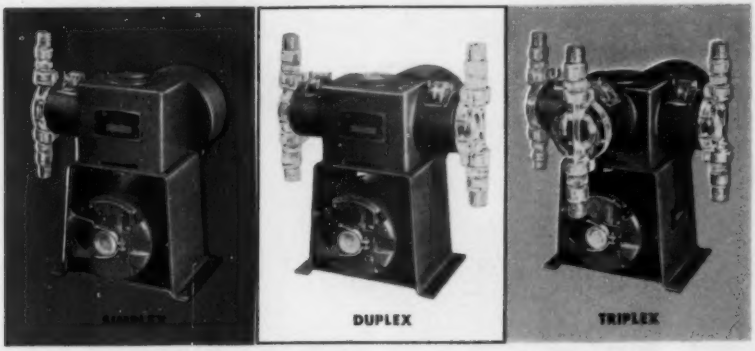

BIF *Proportioneers* CHEM-O-FEEDERS . . .

NEW DESIGN . . . NEW VERSATILITY . . . NEW LOW COST!

Versatile Model 1210 pumps . . . successors to 47 series Chem-O-Feeder and Heavy Duty Midget . . . feed one to three chemical solutions at once . . . accurately, safely, dependably! Complete package . . . ready to connect and start operating.

- Interchangeable measuring chambers handle wide variety of corrosive solutions.
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METERS • FEEDERS • CONTROLS / CONTINUOUS PROCESS ENGINEERING

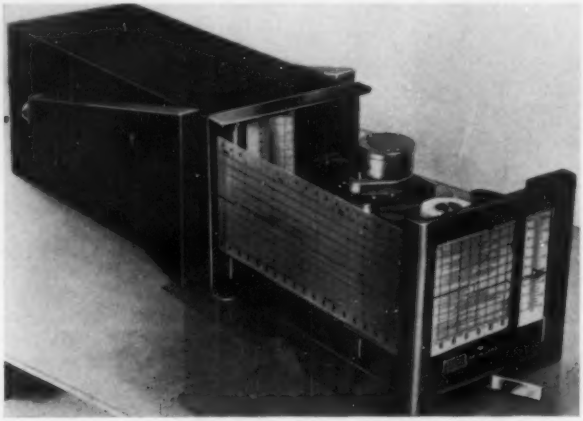
Free bulletin 1210.20-1 gives complete details. Write . . .

B-I-F Industries, Inc., 365 Harris Ave., Providence 1, R. I.

(Continued from page 40 P&R)

Wessex Water Co., Frimley Green, England; left because of ultimatum to shave or quit; available for immediate employment; address Kenneth Lowes.

A new miniature strip chart that can be mounted in a panel area approximately 6 ft square has been developed by Hersey-Sparling Meter Co. The compact unit provides indication, totalization, and recording. It has a six-digit totalizer, dual equivalent scales, and an effective range of 20:1.

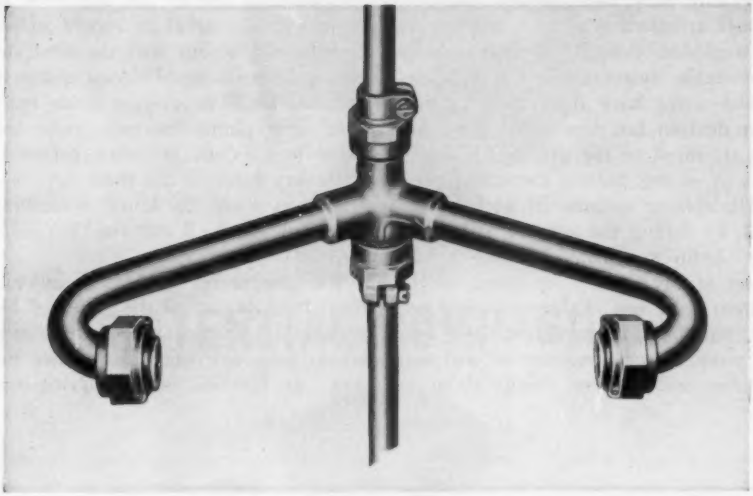


Flow information is recorded on a 4-in. horizontal strip chart for 60- or 120-day periods; when the chassis is removed, 26 hr of records are visible without moving the chart. The unit is suitable for graphic or conventional panels, as well as standard electronic racks.

Remote meter reading in the water works field is, if Badger Meter Mfg. Co., Milwaukee, Wis., and Visi-Meter, Inc., Kansas City, Mo., will forgive us, as old as meter reading itself. Of course, it wasn't until last year that practical remote registers—Badger's "Read-o-Matic" and "Visi-Meter's "Visi-Meter"— were introduced, but long, long before that unregistered remote meter readings were being made from easy chairs in the homes of many meter readers who, on occasion, strayed too far from the water wagon. And the system devised for such readings, which has since been variously characterized as telepathic, empirical, putative, suppositious, presumptive, presumptuous, and just plain crooked, is still employed with understandable frequency. Last reported occasion was early this year in North Miami Beach, Fla., where a since ex-meter reader rendered January and February readings for 23 residences without in the least disturbing the residents—until April, that is, when the results of an actual March reading proved that the telepathy had fallen considerably short, to the point of necessitating installment paying of

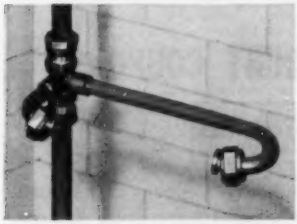
(Continued on page 44 P&R)

NO basement meter mounting can be installed as quickly and easily as Ford's "HANDYHORN"!



The new Ford HANDYHORN (above) eliminates pipe threading, flaring and soldering, puts meter right side up, and provides a permanent physical and electrical connection of the service even when the meter is removed.

Quickest and simplest means of setting meters in basements, the HANDY-HORN can be installed with saw and wrench. It can be used in nearly all vertical piping. Tubes are set at an angle of 120° to permit installation in corners where pipe is at least 2" from wall surfaces.



Where piping is too close to corner . . . the Ford KORNERHORN can be employed. Like the HANDYHORN, this mount does not require flaring or soldering . . . and is quick and easy to install.

Convenient, durable and attractive, the HANDYHORN is the modern way to mount water meters . . . reduce installation costs.

For more information, write . . .

FORD

FOR BETTER WATER SERVICES

THE FORD METER BOX COMPANY, INC. Wabash, Indiana

(Continued from page 42 P&R)

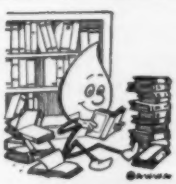
March bills by some of the customers involved.

But if telepathy has fallen short, telephony may soon permit perfectly proper armchair readings. A number of workable, though not economically practicable, systems using leased telephone wires have from time to time been devised, but now AT&T itself has put its mind to the problem with the idea of wiring present meters to present telephone circuits in such a way that, by dialing the number, the utility can obtain a signaled reading of the meter at any time. The details of the system have not all been worked out yet, but the very thought that it may be possible for someone to dial our number and find out things about us without our even knowing of it gives us some cause for concern. Not that we're worried about even as intimate a hookup as one to our television set to provide an accurate record of our viewing habits, but isn't the next step wiring us for sound? As a matter of fact, we begin to wonder if we really need our phone anyway, now that there is a booth at every corner, if not every bend of the road.

If you want to know something, don't call us, we'll call you!

Remote meter reason, meanwhile, must have prompted the states of Nevada and Utah to take the legislative action they did concerning water meters. In Nevada, public service com-

(Continued on page 46 P&R)



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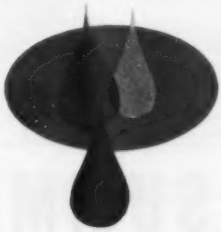

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HALLIBURTON

WATER WELL SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

(Continued from page 44 P&R)

mission law forbids the installation of meters by privately owned water utilities serving communities of more than 4,500 inhabitants. The only utility now affected, since the Las Vegas system was taken over by a municipal district, is that of Reno, which must remain on a flat-rate basis. In Utah, meanwhile, the state engineer has statutory authority to require water companies to meter their systems, although the fact that a majority of the state's 340 systems remain unmetered indicates that the power has not been used. As a matter of fact, a recent bulletin by State Engineer Jerry Tuttle, calls for cooperation, but does not bare legal teeth.

Remote, but interesting, we'd guess.

Morrison B. Cunningham, director of public works at Oklahoma City, Okla., was awarded a citation of appreciation by the city managers on Jun. 28, the 40th anniversary of his employment with the city. He served as President of AWWA in 1954.

U-2, RB-47, and now 2-4-D are numbers associated with bombers in the headlines of late, but whereas the first two proved to be unarmed, the last is being loaded for chemical warfare. It is rather unlikely, however, that the 2-4-D will be either shot or shouted down by the USSR, as its flight pattern will confine it to the reaches of Lake Musconetcong (the name has no relation, as far as we have

(Continued on page 48 P&R)

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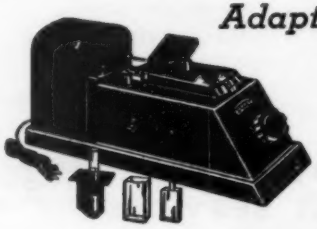

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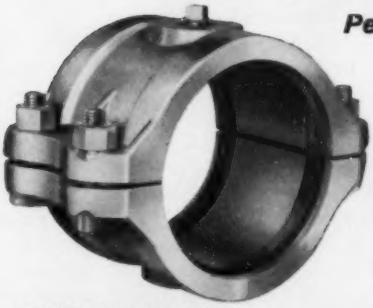


Permits easier, quicker, permanent repair of 4", 6" & 8" transverse cast iron pipe underground breaks

LIGHT WEIGHT Assembled 4" diameter sleeve weighs but 26 lbs. Weight of 6" sleeve is 32 lbs., 38 lbs. for 8" sleeve.

SHORT LENGTH Effective length of 4 inches between end seals on all sizes. Overall length is 6¼".

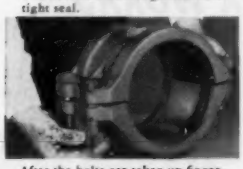
TWO-PIECE ASSEMBLY No end glands. Side and end gaskets are pre-assembled and cemented in sleeve grooves.

HIGH STRENGTH All parts are high tensile and corrosion-resistant. Sleeve halves are 70,000 psi tensile ductile iron. Nuts and bolts are high strength, corrosion-resistant alloy.

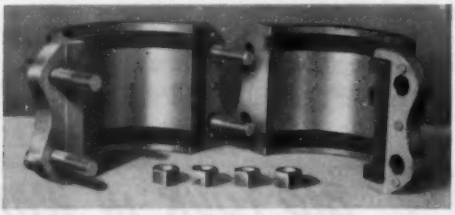
ASSEMBLED IN 3 EASY STEPS

Once the damaged pipe is uncovered, one half of the sleeve is placed on each side of the pipe.

Sleeve halves are drawn together. Pre-assembled rubber gaskets make tight seal.



After the bolts are taken up finger-tight, tightening the four bolts by wrench completes assembly.



HERE'S ALL THERE IS TO IT! Illustration shows two-piece glandless construction. Side gaskets overlap ends of circumferential gaskets for tight seal. Four bolts are only accessories. Tapping boss on each half allows maximum tap of 2 inches. Regularly furnished with one sleeve-half tapped for ¾" pipe.

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(Continued from page 46 P&R)

been able to determine, to the "Musco" in Muscovite, we hope) in northern New Jersey, where it will drop exploding containers of 2-4-D granules in the hope of destroying survivors of the last year's cold war. The "survivors," we hasten to point out, are bottom weeds which defied freezing out last winter when the lake level was lowered for that purpose. And not to implicate the US or its military establishment, we note that the bombing program is being financed with a New Jersey state legislative appropriation of $50,000.

Computerese, the language of the electronic brain, has now been glossarized by the Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Philadelphia, so that laymen will know what its salesman are selling. The 22-page, pocket-size booklet includes 82 terms that should vocabulate you to expertitude. Using the definitions you will quickly appreciate that optimization of the peripheral equipment of an analog computer can produce an overflow readout on the nixie light, we think. Not defined are the acute symptoms of computeritis, computerosis, or complete compusion.

Robert E. Garrett has been elected president and chief executive officer of US Pipe & Foundry Co., Birmingham, Ala., to succeed the retiring Claude S. Lawson. The latter continues as board chairman. Garrett has been a US Pipe vice-president since 1952.

Castroted—completely unmanned, that is—was Havana University's College of Engineering last July as the new pro-Castro supreme governing council of the university dismissed all 28 engineering professors for alleged counter-revolutionary activities. Among the 28 were at least four AWWA members, two of whom—Leandro de Goicoechea and Luis A. Nunez—have served as members of the Board of Directors in recent years. Must be they weren't convertibles.

The 9th annual management short course, sponsored for utility managers and supervisory personnel by the Illinois and Indiana sections of AWWA, will be held at Allerton Park, near Monticello, Ill., on Oct. 24–28. Conducted by the University of Illinois, the course is designed to provide a

(Continued on page 104 P&R)

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Ion-exchange units, designed for quick installation and available in capacities of 2,100–13,200 gph, are discussed in a 4-page, illustrated bulletin. The information on the "packaged" unit is available from Cochrane Corp., 17th St. & Allegheny Ave., Philadelphia 32, Pa.

Radioactivity in water can be detected by a newly developed fluid monitoring system. The bulletin describing the system may be obtained from Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

Steel pipe is the subject of an illustrated, 4-page folder. WSP 9060 may be obtained by writing Product Information Service, Armco Drainage & Metal Products, Inc., Middletown, Ohio.

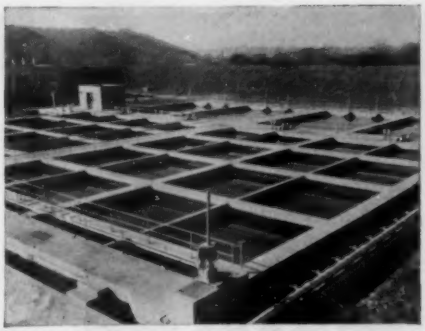
Temperature and pressure recorders are described in an 8-page, illustrated catalog that features detailed photographs and diagrams of the equipment. Catalog 800 is available from U.S. Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.

Electric flowmeters for all types of liquids and gases are the subject of a new 28-page bulletin. Designed for pressures up to 5,000 psi, the meters are described and illustrated with photographs, circuit diagrams, and flow charts. Publication No. 59-5 may be obtained from Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago 47, Ill.

Butterfly valves, designed for pressures up to 125 psi, are discussed in a

(Continued on page 52 P&R)

WATER LEAKAGE PROBLEMS IN CONCRETE STRUCTURES?



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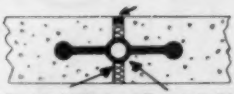

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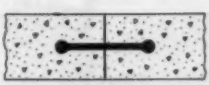

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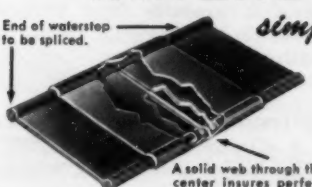
simplifies Field Splicing



Permits a faster, simpler method of field splicing, using only rubber cement. The union is hollow and is made from rubber meeting the same specifications as the waterstop. Available for splicing 6" and 9" Dumbbell and 6" and 9" Hollow Bulb Waterstops. Pat. Pend.

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Service Lines

(Continued from page 50 P&R)

comprehensive 36-page catalog. The information includes, along with photographs and cutaway drawings, general hydraulic data, materials specifications, and operation methods. Descriptions of the rubber-seated valves are in Bulletin No. 5904, available from Darling Valve & Mfg. Co., Williamsport 28, Pa.

Meter settings are completely described and illustrated in a two-color, 43-page booklet recently published. Included are cutaway drawings and specifications for 21 different meter settings. A copy of the booklet, "The Engineering of Water Meter Settings," is available from Ford Meter Box Co., Inc., Wabash, Ind.

Electronic data processing for smaller utilities is the subject of a 6-page brochure, which explains how small companies can make use of facilities offered by special service centers. A copy of the information may be obtained from Remington Rand Div., 315 Park Ave. S., New York 10, N.Y.

Corrosion protection with sodium silicate is covered in a 2-page technical data sheet that discusses treatment processes and correct dosages. The information is available from Philadelphia Quartz Co., 1158 Public Ledger Bldg., Philadelphia 6, Pa.

Elevated steel tanks are the subject of a 20-page, illustrated booklet that makes use of photographs, tables, and diagrams to describe a wide selection of tanks. A copy of "Modern Water Storage in Elevated Steel Tanks" may be obtained by writing Pittsburgh-Des Moines Steel Co., Neville Island, Pittsburgh 25, Pa.

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

INDUSTRIAL WATER USE

Industry and Water Supply in Germany. ANON. *Wasser, Luft & Betrieb* (Ger.), 2: 152 ('58). From the annual report of the *Bundesverband der deutschen Industrie*, figures are given showing the great increase in the industrial water demand of Ger. in recent years. In '55 the industrial demand was more than double the domestic demand. The report discusses means of ensuring maintenance of the supply, the application of the Water Law of '57, the problems of variations in legal requirements in different states, responsibility for the results of poln., protection against poln., revision of the legal powers of river boards, development of standards, encouragement of the individual initiative of industries and finance, and the importance of international cooperation.—*WPA*

Water Supply for Foundries—II. *Wasser, Luft & Betrieb* (Ger.), 2:194 ('58). Descriptions are given of the water systems of foundries in Ger. and Austria. In the Ruhr district foundries are the greatest users of water. Figures are given for the tot. water demand and supplies from different sources for the foundry industry, mining, and chem. works. Methods of saving water include replacement of water cooling by steam cooling and extensive reuse of water. An account is given of the methods of collection, treatment and reuse of water at various plants, with a plan and description of the complete recirculation plant at the *Westfalenhuette*. In Austria statistics of water demand are somewhat scanty but figures are given for different industries in Styria where foundries account for 29.7% of the tot. industrial demand. The water system of the Donawitz works and the introduction of a closed recirculation system and steam cooling are described with a plan, and the effect of recirculation on the polluting material discharged to the river is discussed. An account is also given of the water supply system of the iron and steel works of Linz.—*WPA*

Water Economy in the Factory. P. LIEBEN. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 44:89 ('59). After discussing the various uses of water in industry and the quality of water required for each purpose, the author gives examples of the use of water in paper mills, steel works, and gas works, with special reference to the economic aspects, and outlines methods for improving the economy, especially by preventing wastage; reusing water from one process for another process not requiring water of such high quality; and using suitably chosen and well maintained pumping systems.—*WPA*

Water Economy in the Coal Mines of Belgium. F. EDELINE & R. LEIGEOIS. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 97:19 ('59). An account is given of the uses of water in coal mines in the 5 main mining areas of Belgium. Water is needed for both domestic use (for washing, cleaning, and sanitary requirements), and for industrial use in the plant, where large amounts are required for coal washing, for dust removal, and for the production of steam and cooling water. Water is obtained from rivers, and is reused as much as possible. Waste waters from coal mines are discharged to rivers after treatment, and regulations are presented for their treatment and discharge, to prevent the pollution of surface waters. Treatment of the waste waters is usually by sedimentation, with or without preliminary coagulation. In one plant it is planned to use a cyclone for removal of slime, followed by flotation.—*WPA*

(Continued on page 64 P&R)

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(*Continued from page 62 P&R*)

The Significance of Water Economy in the Steel Industry for the General Water Supply and the Maintenance of the Quality of Surface Supplies. V. BREITLING. *Gas- u. Wasserfach.* (Ger.), 101:73 ('60). A steel plant with a production of 2,000,000 tons/yr will use about 100,000,000 cu ft/yr, equiv. to the usage of a city of 1,500,000 inhabitants. Hence, it is necessary to recirculate as much water as possible. As about 80% of the water is used for cooling purposes, this water must be recooled in cooling towers, with the avoidance of excessive concn. of salts. Acid treatment or addn. of polyphosphates may be useful in some cases. Water used in mfg. processes will generally have to be purified and settled before reuse. Water used for removal of dust in blast furnace gas must be freed from HCN and settled. Water used for scale removal may contain oil and require the addn. of chemicals and skimming. Spent pickling liquors may be neutralized with CaO, and the sludge settled out. Bacteriol. supervision must be used to avoid contamination of recirculated water, and sanitary wastes must be disposed of separately.—*CA*

Water Supply of Siderurgical Works. R. COLAS. *L'Eau* (Paris), 45:259 ('58). Water consumption in the steel industry is greater than in any other industry in France, amounting to 120 cu m per ton of steel produced, or about 1.2 billion cu m/yr, after taking into account a probable recirculation of about 40%. This requirement is discussed in relation to surface and ground water resources, other water demands, and water poln. Examples are given of the water demands and resources of the industrial regions of Moselle and Meurthe-et-Moselle in the east of the country, and of the northern region, both showing the uncertainty of water resources in relation to needs of the pop. and industrialization increase.—*WPA*

Cooling Waters in Siderurgical Works. E. DOHEN. *L'Eau* (Paris), 45:271 ('58). After discussing the quality of water required for cooling purposes in steel works, and the methods of treatment (both physical and chemical), especially to reduce the hardness, corrosivity, and action of living organisms, the author describes the cooling circuit, including facilities for controlling the quality of the water, and indicates the economies which would result from certain improvements.—*WPA*

Energy Aspects of the Problem of Water in Siderurgy. J. SZCZENIOWSKI. *L'Eau* (Paris), 45:263 ('58). The various uses of water in a steel works are discussed from the point of view of the consumption of energy involved in pumping, and the heat lost with the water; and methods for reducing this consumption of heat and electrical energy are suggested. The advantages of the method of cooling by evapn., which is being used more widely in certain countries, such as Germany and Russia, are considered. —*WPA*

Heinz Factory at Kitt Green. ANON. *Engr.* (Lond.), 207:809 ('59). At the new plant of H. J. Heinz Ltd. at Kitt Green, near Wigan, large volumes of water are required for boiler feed, process cooling, and washing. The boiler feedwater is softened by ion exchange, and the washing water is chlorinated. Used cooling water is cooled, filtered, and chlorinated before reuse. The waste waters are screened and stored in balancing tanks before discharge at a controlled rate to the municipal sewers.—*WPA*

Examples of the Use of Water in Closed Circuit. E. CORNUAT & J. DECARREAUX. *L'Eau* (Paris), 45:279 ('58). Two examples are given of the recirculation of water in steel works. The limited quantities of water available for the Sidelor works at Micheville, France, from the river Vacherie, a small tributary of the Alzette, and from a mine at Brehain, led to the adoption of a closed-circuit system which is described and shown diagrammatically. About 94.7% of the water is recirculated, the 5.3% of makeup water amounting to 4.4 cu m/ton. Water supplies for the rolling mill at Mont-Saint-Martin, France, are obtained from the river Chiers and since the water demand can reach 5 times the flow of the river, a closed-circuit water system is necessary. The various uses of water are considered and the 5 water circuits, all using recirculation, are described with the aid of a flow diagram. Cooling water for the furnace is filtered and treated with polyphosphates to prevent formation of scale, but for other purposes physical treatment is sufficient, either filtration through silex (for water used in cool-

(*Continued on page 66 P&R*)

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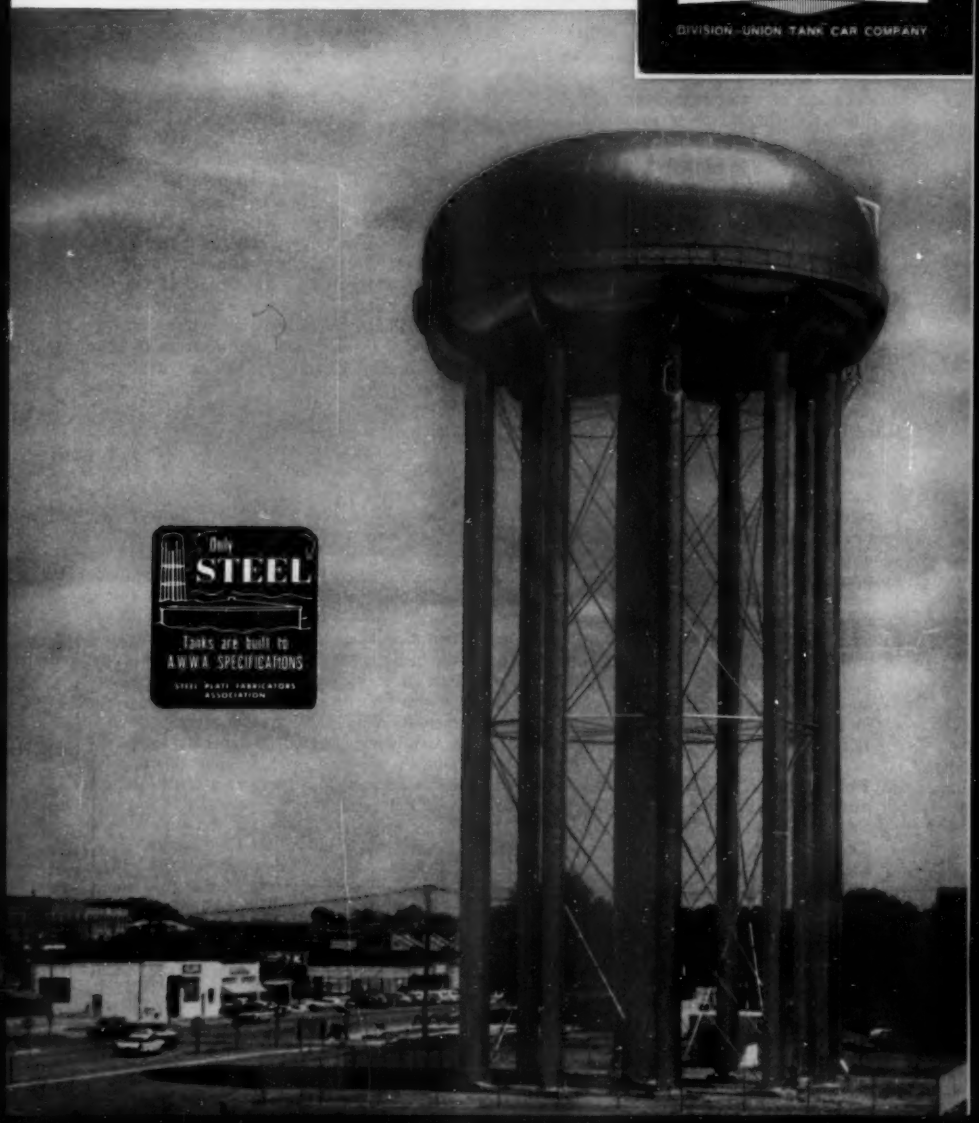

(*Continued from page 64 P&R*)

ing the rollers, in the heat exchangers in the motor room, or in washing the products to remove iron scale) or sedimentation (for water used in transport of scale).—*WPA*

Improvements in Water Economy at the Czarna Woda Fiberboard Mill. A. KULAKOWSKI. *Przeglad Papierniczy* (Poland), 14:1:5 ('58). Methods used for the conservation of water at the fiberboard mill at Czarna Woda (Pol.) are outlined. They include reductions in the amount of water used in thickener sprays and screen showers, and reuse of water in cyclones and on Waco filters. Owing to these measures, the consumption of fresh water was reduced by 37%, but the quality of the products (namely hardboards and porous fiberboards) was not lowered, while the performance of the Waco filters was improved.—*WPA*

The Effect of Surface-Active Agents on the Formation of Boiler Scale. G. H. IRELAND. *Corrosion Prevent. & Control* (Gr.Br.), 12:369 ('58). The mechanism of scale formation in boilers is described, and the part played by various surface-active agents in forming a removable sludge is discussed. A surface-active agent discovered recently, "Belloid FW," which is a neutral salt of an inorganic sulfonic acid, causes particles in suspension in a boiler to repel each other and to remain suspended. This compd. is noncorrosive, nonvolatile, nontoxic, heat stable, and chemically inert, and does not cause foaming or priming. In the presence of this compd., calcium carbonate forms a thin layer of scale which is easily removed by blowdown or shutdown. "Belloid FW" may also be combined with an antiforming agent, hydrazine, ammonia or neutralizing amines to prevent corrosion, and deposits are prevented on its addition, in small amts., to river water or sewage.—*WPA*

Pulp Press Water Return and Water Addition in Continuous Diffusion. B. DIEDEN. *Socker Handl.* (Sweden), 14:97 ('58). Tests carried out on the tower diffuser at the beet sugar factory at Morbylanga, Sweden, have shown that a single water supply comprised of pulp press water and condensate did not give as good results as separate supplies of the 2 waters, the condensate being added at the top of the tower and the pulp press water below the pulp discharge point. Each water supply should be brought to the required temp. and the pH value adjusted to between 5.5 and 6.0. The relations between dry solids in the pulp, pH value of the pulp press water, vol. of water recirculated, and sugar losses are discussed. The vol. of fresh water required is regulated by the quality of the cossettes and the concn. of sugar in the pulp. With good regulation, losses could be reduced by 0.1%. —*WPA*

Recovery and Reuse of Boxboard Mill Effluent. G. N. MINER & R. J. KEATING. *Can. Pulp & Paper*, 11:9:38 ('58). The authors review the treatment of the waste waters at the Stony Brook, N.J., boxboard mill of Whippany Paper Board Co., which had a production capacity of 350,000 lb/day. A solids-contact pilot plant was installed to study sedimentation and the results were used in the design of the final plant. Final plant includes an improved bar screen built in the existing white-water pit for removal of coarse solids, pieces of metal and other undesirable material, an elevated surge tank, a rotary sprinkler for dispersing foam and a sludge-contact sedimentation tank.—*WPA*

Treatment of Waste Waters in the Paper Industry. P. KLENOR. *Papír a Celulosa* (Czech.), 13:132 ('58). The principles of the treatment of paper mill waste waters by filtration, sedimentation, and flotation are reviewed briefly, and the relative advantages and disadvantages of the Joston system, patented in Czech., are discussed. This system combines sedimentation and filtration; the sedimentation tank is built underground, and white water directed into the tank flows by gravity, thus preventing aeration. Sedimentation is facilitated by the stream of water being directed tangentially to the surface of the tank, and the fine fibers, which settle very slowly, serve as a filtration layer. —*WPA*

Water for the Food Industry. H. J. BOURNE. *Tech. l'Eau* (Brussels), 12:133:31 ('58). The author outlines the various methods for the phys. chem. and bacteriological purification of water and describes their application to the treatment of water supplies for specific food industries, includ-

(*Continued on page 70 P&R*)

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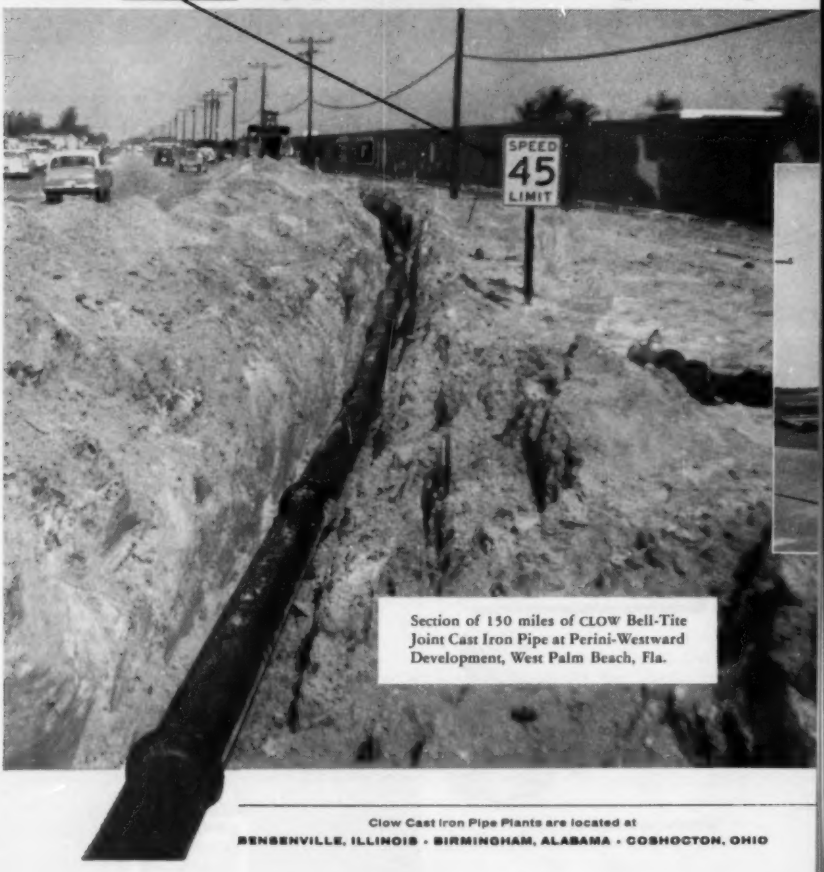

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(*Continued from page 66 P&R*)

ing preserves manufacture, breweries, preparation of beverages and fruit juices and ice production.—*WPA*

Nuclear Power Needs Pure Water. A. C. MULLER. *Chem. Eng. News,* 37:51 ('59). In a symposium on water technology for nuclear applications at the 135th National Meeting of the American Chemical Society he described the water-treatment system which will be employed at the nuclear power plant of Consolidated Edison at Indian Point, N.Y. There will be two principal treatment systems, one treating raw water from the Catskill and Croton watersheds and the other more complex system treating water within the primary loop. Raw water will be softened by cation exchange, decarbonated, evaporated, and demineralized by mixed-bed ion exchange. Cyclohexylamine and hydrazine will be added to reduce corrosion and remove oxygen. Treatment in the primary cooling system will be to remove materials picked up by corrosion and erosion. An excess of hydrogen will be maintained in the water to eliminate the high oxygen concentration. Radioactive contaminants will be removed by ion exchange, and if necessary by gas stripping to remove radioactive gases.—*WPA*

Fuel Reprocessing Series—3. Treatment and Disposal of Fuel-Reprocessing Waste. J. A. LIEBERMAN. *Nucleonics,* 16:82 (Feb. '58). The ultimate disposal of nuclear wastes hinges on 2 major factors: (1) control must be maintained for hundreds of years; (2) permissible environmental concns. are extremely low. Such wastes frequently contain enough ions other than fission products to limit vol. reduction by evapn. Estd. inventories for a relatively modest nuclear-power program, even after removal of Sr^{90}, Cs^{137}, and Pu^{239}, would still require storage of the order of 10 yr. Tank storage is costly and of uncertain life, but will probably continue to be necessary. Heat from radioactive decay introduces special problems but can render evapn. nearly cost-free, although control of entrainment and carryover in any evaporative procedure must be very high. Neutralization is used to reduce corrosion problems, but increases solids content. Pptn. procedures can be used to scavenge Cs^{137}, Sr^{90}, and Pu^{239} with substantial decontamination factors. Ion exchange has been considered, but radiation damage to the resins can be a problem. Crystallization procedures have been investigated and show some promise. To circumvent some of the limitations of tank storage, conversion to stable oxides or fixation in inert carriers has been tried. High temps. and/or fluxing agents yield solids showing substantial volume reductions over concd. aqueous wastes. Radioactive particulate control is an important problem, as is decay heat. Fixation generally involves ion exchange on clays followed by heating to fix activity. Decontamination is good, but volatility of some isotopes at high temps. is an important problem. Little beyond anal. consideration has been done towards ultimate disposal. Safe dispersal to the environment appears unlikely. It may be practical to dispose of wastes into specific formations, e.g., salt domes, synclinal basins, shale formations, or sandstones. Physical and chemical compatibility between wastes and the formation and decay heat are major problems. Disposal in salt structures shows the greatest promise at the present time. The long-term implications of ocean disposal are unpredictable. The problems associated with pyrometallurgical and volatility process wastes differ in degree but not in kind. Present knowledge of these processes is not adequate to define the wastes from them. I^{131} is the most significant gaseous waste from all processes, although krypton is important from a long-term standpoint. Highly contaminated aerosols, particularly of alpha-active materials, result from chem. reprocessing, and require a high degree of filtration for adequate control.—*PHEA*

The Use of Exchange Resins in Supercritical-Pressure Power Stations and Boiling-Water Nuclear-Power Stations. L. WIRTH. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 96:341 ('58). At a meeting in Liege, '58, the author discussed high-rate ion-exchange treatment of water as required for condensate at nuclear and high-pressure power stations, with particular reference to studies on the improvement of the phys. stability of ion-exchange resins for use at such high rates. The results obtained by Sisson in pilot plant tests on mixed-bed ion-exchange treatment of condensate are included. New cationic and

(*Continued on page 72 P&R*)

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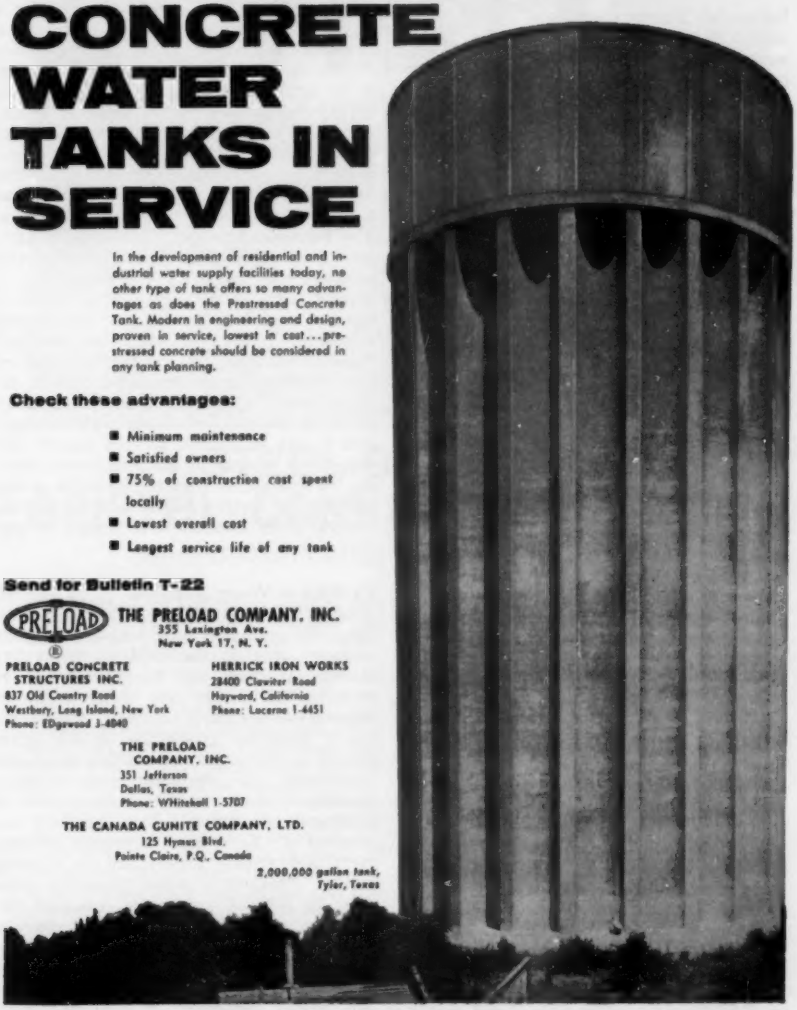

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(*Continued from page 70 P&R*)

anionic exchange resins have been developed, having great physical stability and resistance to fracturing under severe operating conditions; they have been used in mixed-bed ion-exchange units giving very small loss of charge.—*WPA*

Industrial Water Treatment. M. A. HUBERT. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 99:72 ('59). In a paper presented at a meeting of the commission for the study of reagents employed in water treatment, *Centre Belge d'Etude et de Documentation des Eaux*, at Brussels in Jun. '58, the author reviewed the general applications of ion exchange and discussed the application of the process to treatment of industrial water supplies for laundries, distilleries, breweries, textile, chem. and pharmaceutical industries and for the manufacture of soft drinks, oil, margarine, preserves, jams and starch.—*WPA*

Mixed-Bed Ion-Exchange Treatment of Water for Washing Semiconductors. W. F. LORSCH. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 96:338 ('58). At a meeting in Liege, '58, the author emphasized the importance of using pure water for washing the germanium and silicon components during the manufacture of semiconductors (rectifiers, transistors, and photoelectric cells), and described the development of a mixed-bed ion-exchange method for demineralization of the water. The method finally chosen involved recirculation of the washing water through a mixed-bed ion-exchange column, the only fresh water added being that required to make up the losses due to evapn. and adherence to the components. The resistivity of the water leaving the ion-exchange column can be maintained at 16×10^6 ohm-cm. An exhausted ion-exchange column can be replaced by a second column and taken for regeneration without interrupting the demineralization process. The semiconductors are washed first with water from an ordinary mixed-bed-ion-exchange unit, and finally with water from the recirculating system. —*WPA*

POLLUTION CONTROL

Synthetic Detergents and Water Supplies. C. HAMMERTON. *Proc. Soc. Water Treatment Exam.*, 5:2:145 ('56). A study was made of the amt. of surface-active materials present in several rivers in England and the effect of such contamination on water-purification processes. Storage tests of river water over a period of 3 weeks reduced the concn. of surface-active materials 20–50% depending upon temp. conditions. After 6 months, 50% still remained. A combination of storage and filtration through sand showed a redn. of 75%. Chem. coagulation resulted in no noticeable decrease. Activated C was effective but uneconomical to employ. Foaming was found to be the first indication of increased amts. of surface-active substances being present. No evidence was noted that the amts. of such materials indicated had any effect on water-purification processes. The biochem. decompn. of household detergents, including the recent surface-active compds., was examd. It was found that, in general, CH_3 groups are readily attacked; CH or secondary groups are less readily attacked. Tertiary C groups are not oxidized by bacteria. It was further observed that biochem. oxidn. depended almost entirely upon the mol. structure of the alkyl group in the mol. A theory was developed that it may be possible to split anionic surface-active compds. by bacterial action, severing the hydrophilic from the lipophilic group, and thereby destroy surface-activity at once. Several chem. compds. were studied to support this theory.—*CA*

Syndets in Water Supplies. J. M. COHEN. *Soap & Chem. Specialties*, 35:53 (Sept. '59). Synthetic detergents have almost completely replaced soap in the field of heavy-duty washing products and have given rise to problems in sewage and water treatment because of two basic reasons. Almost the entire industrial production of 3.8 billion pounds is discharged to a surface or ground water and ABS, the most common ingredient in synthetic detergents, is resistant to biological metabolism. This resistance has resulted in ABS residues in sewage effluents, river and ground waters and in drinking water. Phosphates, which frequently comprise 40–50% of a synthetic detergent formulation, can interfere with water coagulation and provide additional material for growth of algae. Water treatment processes, including treatment with activated carbon, are largely ineffective in removing ABS, hence drinking water, obtained from an

(*Continued on page 74 P&R*)

Painter applies Torex Heavy with short-nap roller. Torex Heavy is a gray, rubber-base coating, giving 2.0 mil thickness per coat, with a flat finish. Imparts no taste or odor to water.

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(*Continued from page 72 P&R*)

ABS contaminated supply, will contain residues of ABS. Suburban use of small lots for disposal of sewage and for well water supplies has resulted in increasing incidents of contamination of the drinking water supply with ABS.—*PHEA*

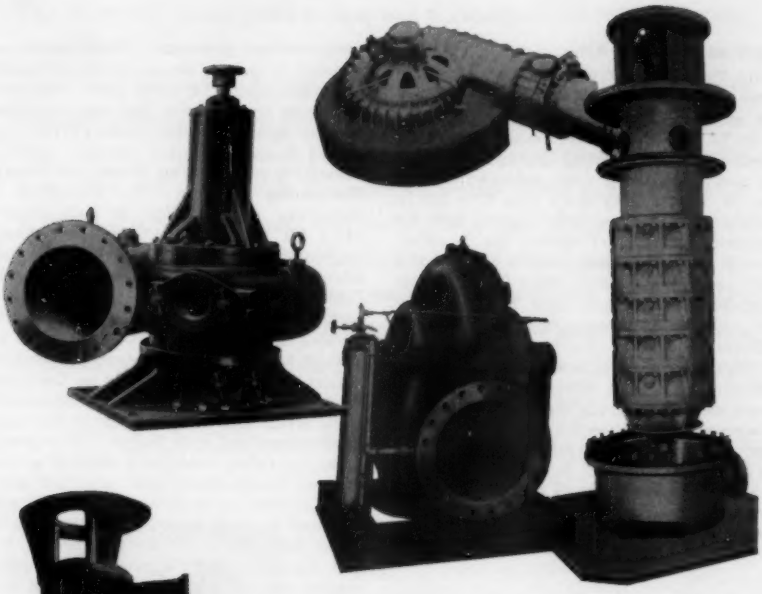
What the States Are Doing About Pollution. R. S. SHAW. *Wastes Eng.*, 30:682 (Nov. '59). Separate discussions are presented by officials or directors of the state water pollution control agencies of the following states: New Jersey, New Mexico, Ohio, Pennsylvania, Texas, Rhode Island, South Dakota, Tennessee, and Wyoming. Present programs and programs in the treatment of domestic and industrial wastes for the abatement of pollution in their respective states are discussed, together with future plans and objectives. Comments relating to policies and requirements governing types and degree of treatment, plant operation and supervision, and the methods of financing treatment plant construction and operation are presented. Developments in treatment methods and trends, utilization of plant effluents, and the need for educating the public in order to enlist its support in financing abatement programs are pointed out.—*PHEA*

Contamination of Soil and Ground Water and Their Autodecontamination. G. FISCHER. *Egeszsegtudomany* (Hung.), 3: 311 ('59). Soil and water investigations were carried out in loess, inundation-sedimentation soil, and sandy soil concerning autodecontamination and the spreading of contamination. Because of its mobility, the Cl ion proved esp. suitable as characteristic indicator of soil contamination. By using both meat ext. and soil ext. agar for the bacteriological investigation, a sep. counting of bacteria derived from human and from animal feces was possible. The excess load on the soil was indicated by a relatively larger increase in the ions of protein ammonium, ammonium, and nitrite. The cause for this proved to be a relative O deficiency, esp. in the bound soils. The autodecontamination in these soils involved adsorption processes; in the loose soils chem. and biol. decompn. processes predominated. A well had to be protected by a protective area of at least a radius of 10 m., in order to prevent seepage from outhouses.—*CA*

Risks to Rural Individual Water Supplies From Fecal Wastes. H. WILLINGER & A. HUEBNER. *Oesterr. Wasserwirtsch.* (Vienna), 10:106 ('58). An investigation is described into the bacteriologic condition of individual water supplies in 8 rural areas in the Bucklige Welt and 6 villages of the Marchfeld in Austria. The types of supply included bucket, shaft, and tube wells and springs. The frequently unsatisfactory conditions of construction and protection of the plants and the MF method used for the determination of fecal *coli* are described. Of 169 plants examined, only 36% produced a *coli*-free water and 64% indicated polln. by fecal material, evidence of which was also given by examination of local conditions. The best results were given by tube wells, of which 90% produced a *coli*-free water; risk to them existed only from the neighborhood of seepage pits and sewage, combined with a permeable soil and a high ground water level. 50% of the springs gave a satisfactory water; risk here lay in the lack of a protective area and unsatisfactory construction of the intake plant and piping. Shaft wells were greatly endangered by fecal pollution; only 15% of those in the Bucklige Welt and 29% in the Marchfeld were satisfactory; dangers lay mainly in the position of the wells and in poor construction. Water from bucket wells can be regarded as equivalent to a surface water. 2 brooks used to supply water for cattle were found unsatisfactory.—*WPA*

Bacteriologic Aspects of Sewage Purification and River Pollution. P. KELLER. *J. Hyg.* (London), 57:4:410 ('57). Rapid industrial development in S. Africa has resulted in an increasing demand for water for all purposes. Consequently it has become urgent to consider the role of purified sewage and industrial effluents in the conservation of water supplies. The exptl. work described at considerable length in this paper consisted in the bacteriologic study, by methods which are detailed, of the effect on bacterial pops. of: (1) conventional sewage treatment (biologic filtration, humus tank sedimentation, sand filtration, and activated-sludge treatment) and (2) further biologic purification by vegetation ponds or *vleis* (ponds with a dense growth of vegetation), algal beds, grass-plots, model rivers and

(*Continued on page 76 P&R*)



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(*Continued from page 74 P&R*)

maturation ponds. Over a period of 4 yr more than 2,500 samples were analyzed and "more than 13,000 results are now available for presentation and discussion." There are a no. of detailed tables of results and a long summary. Conventional sewage treatment up to the sand filter stage reduces the number of *Esch. coli* by more than 99% but as between the humus tank effluent and the succeeding sand filter effluent the % reduction is in general very much less than this and sand filter effluents were found to contain between 200 and 5,000 *Esch. coli* per ml. Of the new ways of treating sewage effluents for final discharge into streams artificial *vleis* were found to be far more efficient than sand filters and best of all were maturation ponds the effluents of which contained only between 1 and 10 organisms per ml. From the results of investigation of the newer methods, it appears feasible to consider the suitability of effectively purified sewage effluents as sources for raw-water supplies for industrial and domestic use.—*BH*

Evaluation of the Ground Water Contamination Hazard From Underground Nuclear Explosions. G. H. HIGGINS. *J. Geophys. Research*, 64:1509 ('59). Radioactivities in ground water collected at Nevada test site since the underground nuclear explosions in Operations Plumbbob and Hardtack Phase II have not been significantly above background, due to the formation of silica glass by the explosion, and the ion-exchange properties of fission products in normal earth minerals and water. The glass formed by the high shock pressures releases less than 10% of its radioactivity when leached with water, and the rock minerals crushed by the explosive forces adsorb several 10's of milliequivalents of fission products per 100 g. The distribution coefficients for adsorption range from 50 to 500,000, depending on the particular fission product and mineral. A theory pertaining to the flow of activity in an ion-exchange medium is developed, and equations for application of lab. data to field expts. are included. Some of the available distribution coefficients are tabulated from the literature on waste disposal. It is concluded from existing information that hazards arising from underground explosions in other media will not give rise to serious contamination problems. Until more experience is gained, measurements of aquifer properties should be made prior to planned explosions to determine that safe conditions exist in each particular case.—*PHEA*

Poisoning of Drinking Water by Sewage Containing Cyanide. W. KNAPP & L. HAMMER. *Arch. f. Hyg. u. Bakt.* (Ger.), 143:7:501 ('59). The increasing decentralization of industry in Ger. during and after World War II has led to the establishment of old and new factories in small towns and country districts. A considerable number of metal and galvanizing works are thus in areas where their cyanide-containing wastes are a potential danger to the purity of the water supply. In most instances adequate precautions and treatment of the wastes have neutralized this danger. The present paper, however, contains a detailed account of the investigations and analyses which were carried out in 3 cases where fish were poisoned by high cyanide concentrations derived from industrial wastes. There is a full discussion of the causes of these occurrences, and the inadequacy of present legal control with recommendations of the action which should be taken for their prevention. —*BH*

FOREIGN WATER SUPPLIES

The Problem of Water in Africa and the Management in the Sahara Regions. Sandy Oases. R. TOURNIER. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 41:219 ('58). The problem of improving the fresh-water resources of dry areas particularly the sandy oases of the Sahara region is discussed, including artificial methods of producing fresh water; use of ground water; increasing the evaporation from the seas which supply the rainfall (Mediterranean Sea, Indian Ocean, Gulf of Aden, and Red Sea); cutting channels through mountain ranges; and the use of water from estuaries and ice from Greenland. The creation of ground water reservoirs in the sandy oases of the Ergs and the lowering of the sea level due to such operations are considered. Land treatment of sewage from the oases would prevent or reduce losses of water. The redirection of river water is also discussed with particular reference to the Niger and the Congo and the linking of the Nile and the Chad to form a connection

(*Continued on page 78 P&R*)

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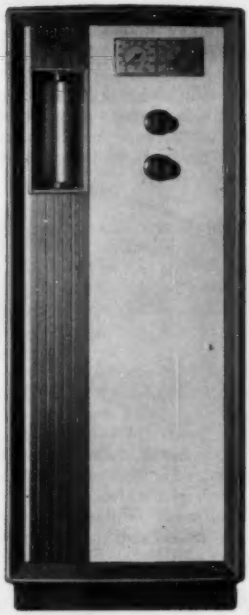

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(*Continued from page 76 P&R*)

between the Red Sea and the Atlantic Ocean, with links to the Congo.—*WPA*

The Problem of Potable Water in Ethiopia. M. A. DUHOUX. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 41:227 ('58). After a brief discussion of the problem of water supplies in Ethiopia in relation to the physical characteristics of the country, the development of potable water supplies for the capital Addis Ababa and for the smaller towns (including Dire-Daoua, Nazareth, and Harar) and rural communities is reviewed historically and the present situation is described. Water for Addis Ababa is drawn from an impounding reservoir at Gafarsa on the river Petit Akaki and treated by coagulation and accelerated sedimentation, rapid sand filtration, and disinfection with gaseous chlorine. The treatment plant at Gafarsa has a capacity of 15,000 cu m/day, and the treated water is of good chem. quality and bacteriologically sterile. It is proposed to increase the capacity of the plant to 35,000 cu m/day, to build the necessary additional reservoirs and distribution facilities, and also to develop a sewerage scheme, on the separate system, and one or more sewage treatment plants using the activated-sludge process with digestion of sludge.—*WPA*

The Problem of Water in French Somaliland. THOLOMIER. *Bul. Centre Belge Etude et Document. Eaux*, 41:225 ('58). The water supply system of Djibouti, Fr. Somaliland, is described. Water pumped from filtration galleries is treated by pressure filtration, coagulation with aluminium sulfate, and disinfection with calcium hypochlorite and sodium carbonate, and pumped to 3 reservoirs, one of capacity 1,500 cu m, and the other two of 400 cu m capacity each. The system supplies a pop. of 25,000 and the port (where 115,000 cu m were supplied to ships in '57). In the future it is planned to increase the water supplies from 5,000 to 10,000 cu m/day, and, by means of electrodialysis, to reduce the chloride content to a level of about 1 g/l and the tot. mineral content to 4–5 g/l.—*WPA*

Water Supply and Water Management (Germany). H. KOESTER. *Gas- & Wasserfach.* (Ger.), 99:829 ('58). An account, illustrated by maps and plans, is given of the problems, present conditions, and future aims in the field of water control and supply in the North Rhine-Westphalian industrial region. The author describes the density and distribution of popn; water resources and the controlling authorities; water resources and conditions of supply in the various parts of the district with special reference to the construction and use of impounding reservoirs and the development of ground water supplies; the treatment of sewage and waste waters, with special reference to problems of poln. of the Rhine; and future plans for water supply and sewage disposal, their costs, and methods of financing.—*WPA*

Problems of Development of Water Supply in Hungary. J. VAJDA. *Wasserbauliche Mitt.* (Budapest), 1:5 ('58). The author discusses the increasing industrialization and growth of pop. in Hungary and the associated problems of water supply. The demand is mainly covered by ground water supplies, and to insure sufficient supplies in future charting of the quality and quantity of ground water is necessary. The preparation of quality charts of surface water should be accelerated in order that their suitability for industrial and other purposes may be assessed. Future requirements in domestic supplies and the costs of the required plant are discussed.—*WPA*

Condition of Water Supply in Hungary. I. HOLLO. *Wasserbauliche Mitt.* (Budapest), 1:8 ('58). At the end of '55 about 25% of the 10,000,000 inhabitants of Hungary were supplied by public water works; supplies for about 42% were hygienically unsatisfactory. Demand varies between 30 and 130 liters per capita per day. Output of existing water works must be increased by 30% to meet the demand. 78% of supplies are taken from ground water, 11% from artesian water, 9% from karst water, and 2% from surface water. Surface water will have to be used more in the future and treatment must be improved. Villages are generally supplied by wells and many supplies are unsatisfactory.—*WPA*

Future Plan of Water Supplies in Poland. A. TUSZKO. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 90:219 ('58). In a paper presented at the water confer-

(*Continued on page 80 P&R*)

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(*Continued from page 78 P&R*)

ence of the *Centre Belge d'Etude et de Documentation des Eaux*, at Liege in '58, the author deals first with the distribution of pop., industry, agriculture, and water resources in Poland, and the use of some of these sources of water, mainly rivers, for navigation, sport, fishing, the tourist industry, and recreation. In the second part of the paper, the water demand and water supplies of Poland are discussed. In some areas, notably river basins such as those of the Vistula and the Oder, supply exceeds demand, and industrial development has provided storage reservoirs and treatment plants, but in the areas between the rivers not supplied by them, and which are agricultural, in some years the lack of water is a serious problem, and means are being devised for transporting water from the rivers to these areas where it is most urgently needed. Watercourses, existing and planned reservoirs, and hydroelectric plants, are indicated on an accompanying map.—*WPA*

The Protection of Water Sources and the Development of Water Supplies in the USSR. M. KOGAN. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 90:227 ('58). In a paper presented at the water conference of the *Centre Belge d'Etude et de Documentation des Eaux*, at Liege in '58, the author discusses the protection of ground and surface water resources in the USSR, particularly against the effects of the discharge of trade waste waters; the treatment of trade waste waters either at the original plant, or, if they contain organic matter, at sewage works, to prevent contamination of water supplies; the standards for potable water supplied with and without treatment; and the history of the growth and development of water supplies in the USSR. Water treatment, as carried out in Russia, is described, with particular reference to the processes of sedimentation, filtration, and disinfection. The installation of a system of drains for sucking the water through the sand of filter beds has almost doubled the

(*Continued on page 82 P&R*)

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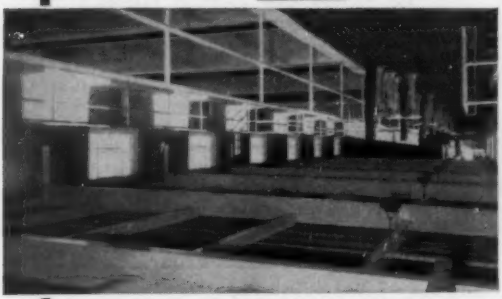

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normal rate of filtration, sedimentation is carried out in contact clarifiers, and disinfection is often effected by means of ultraviolet rays. Sewage treatment by biological methods using a "biocoagulator," or by aeration and sedimentation, research on the softening and demineralization of water, and the removal of iron from water, the prevention of corrosion of water mains and pipes, fluoridation and defluoridation of water supplies, and hydraulic studies, are outlined briefly.—*WPA*

FEEDING, CONDITIONING, AND SEDIMENTATION

Symposium on Handling and Feeding Chemicals to Water-Treating Equipment. T. P. HARDING ET AL. *Proc. 19th Ann. Wat. Conf., Engrs. Soc. West. Pa.*, p. 97 ('58). The properties of concentrated sulfuric acid are discussed in relation to the problems of safe handling, storage, and dilution, which are involved in its use for regenerating cation-exchange resins. The precautions to be taken in handling caustic soda, used for the regeneration of anion-exchange resins, are outlined; and 2 regeneration systems, one automatic and one manually controlled, are described with the aid of flow diagrams. The polluting effect of waste waters from water treatment plants is discussed, including the contribution of some individual treatment processes, namely softening (by hot or cold lime or lime-soda processes), filtration, sedimentation, zeolite softening, and demineralization. Brief suggestions are made for treating the waste waters from each process. Advice is given on the preparation and handling of chemical solutions used in the clarification and softening of water, including the conditions under which solns. are preferred to dry chemicals, the recommended concentrations of solns. of commonly used chemicals, the type and degree of mixing required, the time required for complete soln., the design and operation of soln-feeding equipment, and the point at which the chemical should be added. The importance of accurate, reliable methods for feeding chemicals is emphasized; and examples are given of the feeding of lime slurries, liquid alum, insoluble coagulants, and polyelectrolytes. The conditions under which dry chemicals are more suitable than solutions for clarification and softening of water are outlined, and advice is given on the choice of feeding equipment. Both volumetric and gravimetric feeders are discussed and shown in diagrams and photographs, and the operation and maintenance of the equipment are considered.—*WPA*

A Water Clarification Method With Suspended Sediments. I. I. BELYAEV. *Gig. San.* (USSR), 4:7 ('59). An efficient study of water clarification with suspended sediments made in '57 at one of the water filtration plants in Gorky, proved to render a sufficiently high degree of purification. The best results were obtained during the period from Apr. to Oct. A decrease in the amt. of sediment in the incoming water and a fall in its temperature had an unfavorable effect on the degree of water purification. Sedimentation tanks with suspended filtrating material may be used successfully at water plants provided with a 2-stage water treatment system.—*PHEA*

Process for Clarifying Water. ANON. *J. Appl. Chem.* (London), 8:ii–347 ('58). A method for the clarification of water is claimed. A flocculating agent, consisting of a vegetable or animal colloid and a polyelectrolyte, is added to the water to remove suspensions of colloidal particles. Colloids suitable for incorporation in the flocculating agent are gelatin, gum arabic, pectin, casein, alginates or cellulose derivatives. Suitable polyelectrolytes include sodium or ammonium polyacrylate or a copolymer, such as maleic anhydride-polyvinyl acetate or acrylic acid-ethyl acrylate-acrylonitrile. The method can be used for the treatment of clay suspensions and coal-washing waters.—*WPA*

The Continuous and Accurate Proportioning of Liquids Under Variable Flow Conditions With Particular Reference to a New Method. W. J. WALKER. *Trans. Inst. Chem. Engrs.*, 37:9 ('59). An illustrated description and mathematical analysis are given of a system devised for dosing water with another liquid such as a salt solution, without using metering devices or other obstructions, and without interfering with the free flow of water. The system is based on a flotation tank method, the first arrangement consisting essentially of a drum containing the salt soln., floating in a larger drum containing the water supply. The small drum has a false bottom enclosing an

(Continued on page 84 P&R)

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(Continued from page 82 P&R)

air space. Both drums are open to the atmosphere. The delivery of solution from the smaller tank and water from the larger one is controlled by valves which are calibrated to provide accurate control over the dosage ratio. It is shown that, with this apparatus, variations can occur in the dosage ratio, but these variations are reduced in a second system in which the larger drum is closed and the smaller inner drum is supported partly by flotation and partly by a spring. The modified equipment required for the proportionate mixing of 3 liquids is also described. It is shown mathematically that the spring system can be designed to give a constant proportioning ratio irrespective of the rate of flow of water or of the levels of water and soln. in the tanks.—*WPA*

LABORATORY METHODS

Methods of Particle Size Analysis. F. EDELINE. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 101:139 ('59). On the basis of results previously reported, the following methods were adopted for particle size analysis in studies on water treatment. For granular particles (greater than 200μ), the wet-sieving method is used; fine powders are analyzed by a sedimentation method using the Stairmand apparatus; and powders containing particles of a wide range of sizes or mixtures of particles of different densities are examined by a microscopic method. Details of these methods are given, including the calculation of the results. Investigations are being made of the possibility of extending particle size analysis to flocs or coagulated material, without destroying or changing them.—*WPA*

The Inverted Microscope Method of Estimating Algal Numbers and the Statistical Basis of Estimations by Counting. J. LUND; C. KIPLING; & E. CREN. *Hydrobiologia* (Neth.), 11:143 ('58). Methods of estimating algal populations are compared, and a method of counting based on

(Continued on page 86 P&R)

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(*Continued from page 84 P&R*)

that of Utermoehl and using an inverted microscope is described in detail, including the design of the microscope and the sedimentation tubes, the sedimentation procedure, and the counting procedure. The method is not suitable for nannoplankton, for which the use of specially designed counting chambers is preferable. Results obtained using the microscope method were compared with those obtained using a hemocytometer, and a modified procedure is described for the use of this instrument with algae. The counting method is applicable to samples from any source, provided random distribution occurs, or can be easily produced, for example by shaking. The method of collecting the plankton samples using a rubber hose is described. Statistical methods are presented for determining the precision of single counts and testing for randomness; and the types and magnitude of possible errors are discussed.—*WPA*

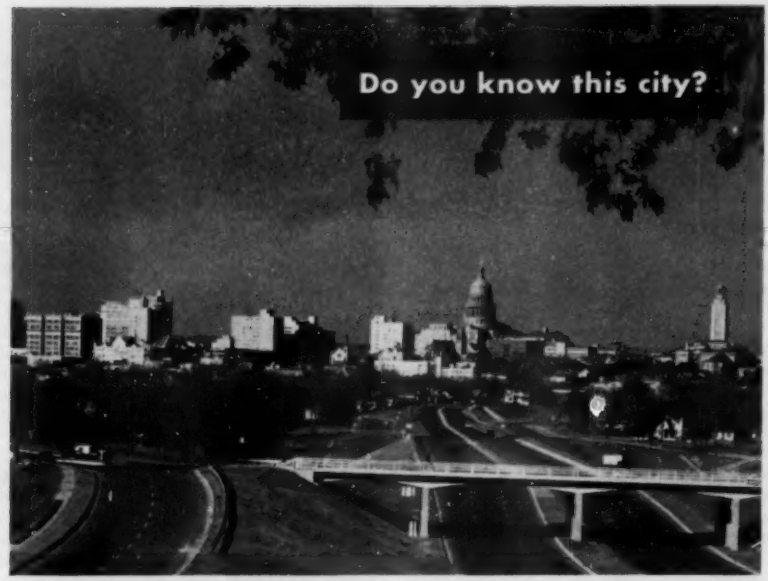
Indigo-Carmine Method for the Colorimetric Determination of Low Concentrations of Dissolved Oxygen in Water. G. P. Alcock & K. B. Coates. *Chem. & Ind.*, p. 554 ('58). Lab. and plant investigations of the indigo-carmine method for the colorimetric detn. of low concns. of dissolved oxygen in water are described. Lab. tests were made on both distilled water and boiler feedwater, and the results were compared with those obtained with a meter using a Hersch cell. It was found that the color standards obtained were sufficiently stable to make the method satisfactory for normal use. For plant tests, several modifications to the technique were made. A special glass reaction vessel was designed to enable color comparisons to be made easily and to avoid the necessity of carrying bulky color standards, and the use of special indigo-carmine-glucose tablets facilitated quick prepn. of stock solns. of indigo-carmine. Sampling technique is described. Results were found to correspond closely with those obtained by the orthotolidine method, and it was concluded that the method was satisfactory, and that it should prove valuable for routine control work, as it is neat and quick. No work on possible interfering substances has yet been carried out, but the method gave satisfactory results with several typical boiler feedwaters. Tables of results, and a diagram of the reaction vessel, are included. —*WPA*

Colorimetric Determination of Hydrogen Dissolved in Water. R. H. Robinson & D. B. Conklin. *Anal. Chem.*, 31:1598 ('59). A method has previously been suggested by Stahlberg and Isoniemi for the detn. of hydrogen in water by adding an excess of alkaline permanganate and allowing the reduction of permanganate by molecular hydrogen to proceed at air temp.; the absorbance of the reduction product is measured spectrophotometrically. This method has now been studied for the detn. of hydrogen dissolved in waters used to test nuclear reactor components. Detailed procedure is given. It was found that alkali appeared to have no significant function and that the reaction was most rapid if the sample was heated to 75°C. The pH value was stabilized with a monosodium hydrogen phosphate buffer.—*WPA*

Colorimetric Determination of Nitrates. J. M. Pappenhagen. *Anal. Chem.*, 30:282 ('58). In a method for the detn. of nitrate, the nitrates are reduced by alkaline ferrous sulfate with silver sulfate as a catalyst, and the ammonia formed is separated by steam distillation and determined colorimetrically using a pyridine-pyrazolone reagent. Using a spectrophotometer with matched 1-cm cells, the procedure is satisfactory for samples containing 0.01 to 0.10 mg of nitrate nitrogen. Nitrates are detd. as nitrate nitrogen from a calibration curve of mg of nitrate nitrogen plotted against absorbancy. If ammonia is present in the original sample it is removed by a cation-exchange resin such as Nalcite HCR; if nitrites are present, they are detd. on a separate portion of the sample and their nitrogen equivalent is subtracted from the tot. nitrogen value found by the reduction method. Other ions which might interfere in the pyridine-pyrazolone method are removed by the steam distillation. The results of analyses indicate that the method is suitable for detg. nitrates in river water and in sewage effluent, but not in crude sewage.—*WPA*

A New Procedure for Rapid Determination of Nitrate and a Study of the Preparation of the Phenolsulfonic Acid Reagent. K. R. Middleton. *J. Appl. Chem.* (London), 8:505 ('58). A rapid method for the detn. of nitrate in dilute aqueous solns. is described. Different methods of preparing the phenolsulfonic acid reagent were com-

(*Continued on page 88 P&R*)



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(*Continued from page 86 P&R*)

pared, and it is concluded that fuming sulfuric acid may be omitted, that considerable variations in the proportion of sulfuric acid to phenol are permissible, and that heating for more than 2 hr makes no significant change. Reproducible results are obtained when nitrate soln. is added to the phenol-sulfonic acid reagent, but not if the order of addition is reversed. It is concluded that phenoldisulfonic acid may be conveniently replaced by phenol-*p*-sulfonic acid, which is easier to prepare and which is sensitive to 2.5 ppm nitrate nitrogen.—*WPA*

A Single-Solution Method for the Determination of Soluble Phosphate in Sea Water. J. Murphy & J. Riley. *J. Mar. Biol. Ass. U.K.*, 37:9 ('58). A mixture of sulfuric acid, ammonium molybdate, and ascorbic acid can be used as a single-soln. reagent for the detn. of phosphate in sea water. Development of the molybdenum-blue color is complete in 24 hr at room temp. and in 30 min at 60°C, and the color is stable for at least 3 days. Beer's law is obeyed up to a concn. of at least 500 μg of phosphate-phosphorus per liter. The salt error is approximately 4% with sea water of chlorinity 19.3 per 1,000. The interference caused by arsenate and silicate is negligible at the concns. at which these ions occur in sea water.—*WPA*

On the Volumetric Estimation of Fluoride by Thorium Nitrate. D. Patnaik; I. B. Mishra; & K. Tripathy. *Current Sci.* (India), 28:328 ('59). In the Willard and Winter volumetric method for the detn. of fluoride with thorium nitrate using alizarin red S as indicator, the adsorption of the red-colored complex on the thorium fluoride ppt. makes observation of the endpoint difficult. A modification of the method is now suggested, involving filtration of the thorium fluoride ppt. before the endpoint is reached. For this method it is necessary either to know the approx. vol. of thorium nitrate soln. required or to carry out a prelim. rough titration until the red color appears. Detailed procedure is given.—*WPA*

Absorptiometric Determination of Aluminum in Water. R. F. Packham. *Proc. Soc. Water Treatment Exam.*, 7:2:102 ('58). The hematoxylin, Alizarin Red S, AWWA aluminon, and Poole and Segrove aluminon methods of analysis were investigated to det. the most reliable one for the detn. of Al. Linearity of the relation between the absorption and concn., sensitivity, and stability of the final coloration were the criteria of suitability. The hematoxylin method is unsatisfactory because sensitivity varies with Al concn. This method does give high sensitivity at low concn. The Alizarin Red S method is convenient, gives linear calibration plots and stable solns., but only half the sensitivity of the P. and S. method. The AWWA aluminon method is unsatisfactory because of poor sensitivity. The P. and S. method was superior to all others for overall accuracy. Modifications are suggested, and the interference from common ions is reviewed. A technique for removing fluoride interference is suggested.—*CA*

A Direct-Plating Method for the Precise Assay of Carbon-14 in Small Liquid Samples. C. C. McCready. *Nature* (London), 181:1406 ('58). A direct plating method for the precise assay of carbon-14 in small liquid samples is described. 0.8 ml of the sample is pipeted into a planchet containing 16 agar blocks, and the planchet is then heated in a saturated atm. to disperse the agar, thus immobilizing the liquid in a uniform layer of dilute gel. The planchets are then exposed to a current of air under an infrared lamp and after about 1 hr the gel dries to a hard, stable, uniform film suitable for assay under an end-window counter. Less than 20% of the radiation from the carbon-14 in the agar film is lost by self-absorption. Limitations of the method are outlined.—*WPA*

A Direct-Plating Method for the Assay of Radioactive Isotopes in Aqueous and Alcoholic Samples. H. Campbell; H. Glastonbury; & M. Stevenson. *Nature* (London), 182:1100 ('58). A modification of the McCready method (see preceding abstract) for the rapid detn. of radioactive isotopes in aqueous and alcoholic samples is described. 0.1 ml of a 0.1% aqueous soln. of agar is pipeted onto a planchet previously washed with carbon tetrachloride and an equal volume of the sample is added and mixed by stirring with a fine wire. The planchet is then placed on a hotplate at about 60°C and allowed to dry, forming a thin, invisible film. Using an end-window

(*Continued on page 90 P&R*)

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(Continued from page 88 P&R)

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Spectrophotometric Determination of Monomeric Silica and of Its Lower Polymers in Natural Waters.—I. The Silicomolybdic Complex. B. VISINTIN & S. MONTERIOLO. *Rend. ist. Super Sanita* (Rome), 22:773 ('59). The molybdate reaction for silica in water, as described in *Standard Methods*, was studied by means of its absorption at 4000 A. The interference of phosphates was suppressed by adding 10% aq. oxalic acid. While the contact time with HCl was without effect on the color produced, the molybdate reagent required 2-3 min to reach its max., and no further color was produced in as much as 25 min. After oxalic acid addn. the color began to weaken after 5 min; this led to the adoption of 2-min contact time before making the reading. Reaction temps. of 17–24° slightly affect the result (slightly less than 0.5 mg SiO_2/l found for each added degree). Light was without influence on the color obtained. A reference curve with known silica solns., and distd. water as a control, showed that the method is suitable for concns. of 0.2 to 80 mg SiO_2/l, but it is most sensitive for less than 40 mg SiO_2/l. Analysis of water from the Fabio well of Lacco Ameno (a water contg. 22.468 g solids/l, of which 11.7894 g/l is chloride; the well is 80°, and has a pH of 7.01) indicates a content of 164 mg SiO_2/l. Water aged for 7 months showed hardly any change in this concn.; it is concluded that SiO_2 is present as H_4SiO_4 and does not undergo polymerization on aging.—*WPA*

WELLS AND GROUND WATER

New Experiences With Horizontal-Filter Wells and Galleries and Wells Constructed in the River Bed. J. VARGA. *Wasserbauliche Mitt.* (Budapest), 1:21 ('58). Details are given of experiences with a horizontal-filter well group in the south part of Budapest, dealing with the yield and the

(Continued on page 92 P&R)

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(*Continued from page 90 P&R*)

influence on the filters and the ground water of the level of the Danube and the deposition of oil and tar from waste waters on the bed of the Danube. The construction of horizontal-filter wells, the effect of wells on each other, and the advantages and disadvantages of horizontal-filter wells in the river bed are discussed.—*WPA*

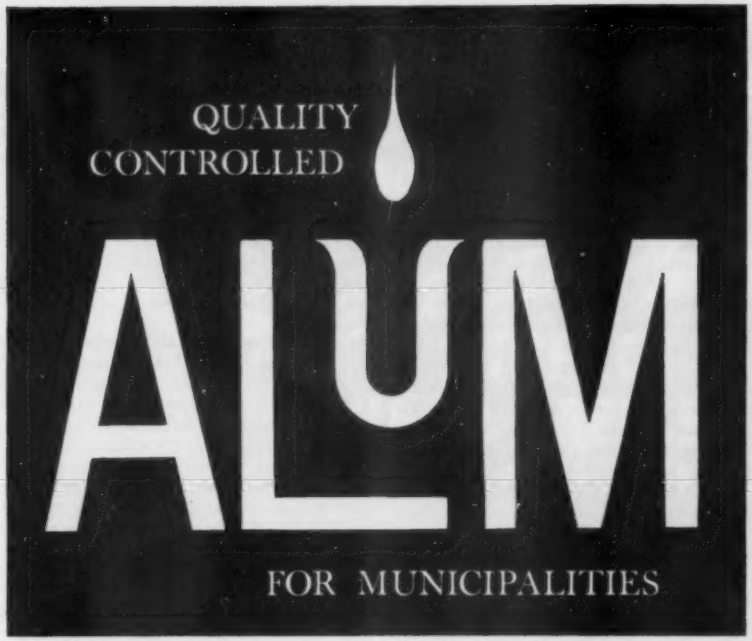
Yield-Depression Curves of Discharging Wells, With Particular Reference to Chalk Wells, and Their Relationship to Variations in Transmissibility. J. INESON. *J. Inst. Water Engrs.* (Gr.Br.), 13:119 ('59). The author discusses the development and interpretation of yield-depression curves, showing the relation between the drawdown of water level in a discharging well and the rate of abstraction. Observations are reported from discharging wells in various types of aquifer, and it is concluded that 2 well defined groups of yield-depression curves can be differentiated, namely type and breakaway curves. In the development of ground-water resources for water supply, it is important to predict the yield characteristics of a well during production, and therefore to determine the category into which the yield-depression curve will fall; a method is suggested based upon a statistical relation between values of transmissibility determined in the discharging well at nonsteady state and the position of the actual yield-depression curve within the family of type curves. The method is based on the analysis of data from chalk wells, but similar methods of comparison may be possible for discharging wells in other aquifers.—*WPA*

The Movement of Ground Water as Influenced by Geological Factors, and Its Significance. J. INESON. *J. Inst. Water Engrs.* (Gr.Br.), 13:49 ('59). The author reported an analysis of the movement of ground water, based on the individual components of Darcy's law, with reference to aquifers in England, and discussed the factors affecting the velocity of movement of ground water. Nonsteady and steady state flow around a discharging or recharging well was analyzed to determine the formation constants of an aquifer, both real and apparent values being derived; and the interrelationship between the formation constants and their importance in hydrologic surveys were considered. Within defined statistical probability levels, the formation constants of an aquifer can be derived from an analysis of yield-depression curves. Particular consideration was given to the movement of water in chalk aquifers, and its relation to the exploitation of ground water resources and the problems of overdevelopment. Progressive changes in the chemical characteristics of ground water have been established, under both natural and artificial conditions.—*WPA*

Evaluation of the Ground Water Sources From Territories Polluted With Radioactive Products From Uranium Fission. A. S. BELITSKII. *Hyg. & Sanit.* (Moscow), 23:10:23 ('58). The author discusses the danger of contamination of ground water supplies with radioactive products from uranium fission. It has been found that ground water supplies remain uncontaminated if the overlying strata are thick and consist of clay and sandy loam but where poln. does occur, the radioactive substance travels in the direction of the flow of water. An equation has been derived for detg. the extent of the poln. zone. Ground waters are the best protected water sources in respect to poln. by radioactive substances, provided there are no abandoned drill holes or quarries.—*WPA*

Rates of Flow of Underground Water and the Choice of Tracers to Determine Them. T. WALDMEYER. *J. Inst. Water Engrs.* (Gr.Br.), 12:389 ('58). Owing to the rapidly increasing demand for water, there is growing interest in schemes for recharge of ground water with surface water, purified sewage effluent, and other waste waters; in connection with these schemes further information is required on the movement of ground water. Work on the flow of water in formations of chalk, carboniferous and magnesian limestone, and sand and gravel is reviewed and indicates that the rate of travel of ground water varies from 0.04 ft/hr in sand to about 750 ft/hr in highly fissured formations; rates of about 10 ft/hr are found for artificial recharge conditions in sand and gravel, and possibly for flows in normally fissured chalk or limestone. Work on the use of tracers is also reviewed. An account is given of hydrogeological investigations carried out in connection with

(*Continued on page 94 P&R*)



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(*Continued from page 92 P&R*)

an application from Aylesford paper mills to abstract a further 1.5 mgd of ground water, in addition to the 3.5 mgd already extracted from boreholes. The studies involved digging a series of observation boreholes. The rate of flow of water between the various boreholes was determined by means of a tracer technique using lithium and potassium salts and detecting their arrival at the boreholes by a flame photometer. The rates of flow were found to range from 530 to 3,360 ft/hr, which confirms the highly fissured nature of the Hythe beds where the boreholes are situated. Typical rates of flow between various points in the area are shown on a map and discussed in relation to the structure of the aquifer. The results indicate a very free flow of water in a wide area around the main boreholes and support the theory that water may be entering the area from the nontidal part of the river Medway; this would explain why the general water level has not fallen even though theoretical calcns. predicted nearly 10 yr ago that the tot. yield of the boreholes could not be maintained. It is hoped that a further supply of water will be obtainable from two 24-in. boreholes which are now being drilled. As a result of these studies, potassium salts, particularly acetate, can be recommended as tracers for similar work when used with a flame photometer for detecting traces of potassium in water.—*WPA*

CORROSION

An Investigation of Chemical Variables Affecting the Formation of Films on Copper in Aqueous Solution. W. H. Davenport; V. F. Nole; & W. D. Robertson. *J. Electrochem. Soc.*, 106:1005 ('59). Electrometric measurements demonstrated that film growth on Cu in air-stirred chloride soln. is at a max. when concn. is 0.01*M* and pH is in the range 5.9–9.0. Only Cu_2O is reported to be present until the pH is >10.5, when the rate of film growth again increases and CuO is said to be present. In equimolar soln. of NaCl and Na_2SO_4 the rate in chloride is about double that in the sulfate, and in both cases it is limited by the availability of O.—*IM*

Corrosion of Aluminum Alloy in Glycol-Water Cooling Systems. N. S. Dempster. *Corrosion*, 15:395t ('59). Mechanism of corrosion of the Al alloy 52S is discussed, and results are given of tests on 25 inhibitor solns. These coolant solns. contained from 0.3–2 ppm of Cu in soln. Cu accelerated the corrosion of the alloy in glycol–distd. water solns. This corrosion was accelerated by using tap water contg. only 10–15 ppm chloride. On the basis of lab. trials conducted on a cyclic temp. basis in ethylene glycol–distd. water mixtures, 2 inhibitive systems, based on (1) Na tetrasilicate plus $Na_2B_4O_7$, and (2) the same mixt. with the addn. of Na cinnamate, can be recommended for service trials.—*CA*

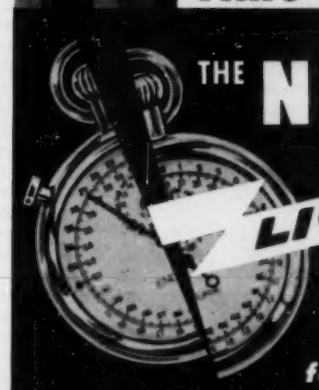
Selecting Corrosion and Scale Inhibitors for Cooling Water. H. Shields; L. V. Sorg; & R. L. Stutz. *Corrosion*, 15:233t ('59). Corrosion inhibitors for refinery cooling water were subjected to 4 phases of testing: bench-scale, pilot plant, small size com. cooling tower, and full plant scale. Only 3 of the inhibitors investigated in the past 9 years were given full-scale trial. Of these, only the chromate type proved satisfactory in all phases of testing. Org. chromates were found to be particularly effective for the river water used in the refinery concerned. Phosphates, while exhibiting fair corrosion protection, had the disability of depositing scale, even at low pH values. Tests were run for both C steel and Admiralty metal. Metal-penetration rate and scale deposition data are given for specimens used in bench and pilot-plant tests in the presence of phosphate and chromate inhibitors.—*CA*

Scale Deposits and External Corrosion in Steam Generators. F. Mastrorazio. *Riv. Combustibili* (It.), 13:347 ('59). Scale deposits and external corrosion in oil-fined boilers are examd. as to their causes (such as fuel ash components, acting on high temp. areas, and S, which acts mainly on low temp. areas). Damage can be attenuated by special equipment designs, by using corrosion-resistant materials, by certain operation and maintenance expedients, and by using fuel oil additives (such as liquid amines or gaseous NH_3).—*CA*

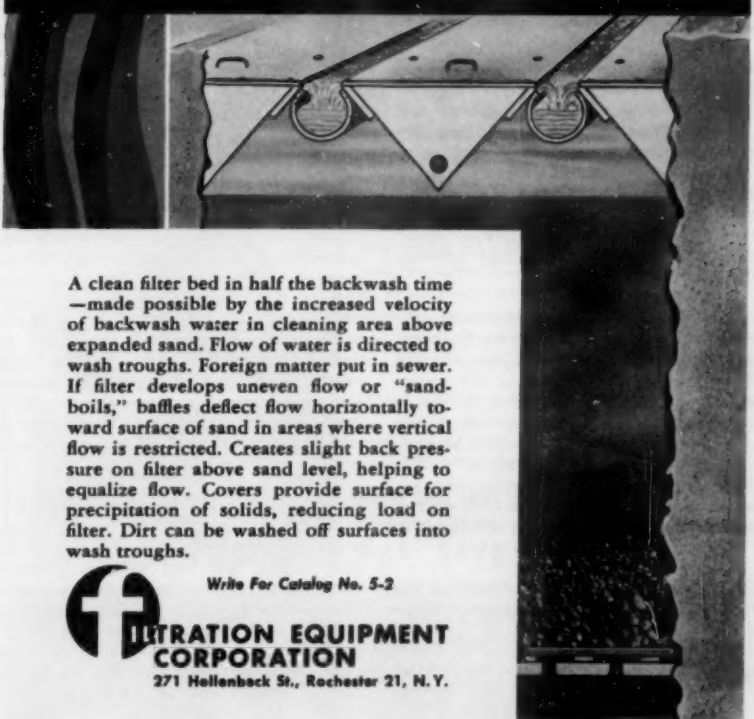
Pitting of Aluminum in Synthetic Waters. D. E. Davies. *J. Appl. Chem.* (London), 9:651 ('59). Factors affecting the corrosion of aluminum by water were investigated by exposing test specimens to synthetic waters, prepared from distilled

(*Continued on page 96 P&R*)

Cuts Backwash Cleaning Time in Half . . .



THE NEW feco LIGHTNING SURFACE WASH BAFFLES for RAPID SAND FILTERS



A clean filter bed in half the backwash time —made possible by the increased velocity of backwash water in cleaning area above expanded sand. Flow of water is directed to wash troughs. Foreign matter put in sewer. If filter develops uneven flow or "sand-boils," baffles deflect flow horizontally toward surface of sand in areas where vertical flow is restricted. Creates slight back pressure on filter above sand level, helping to equalize flow. Covers provide surface for precipitation of solids, reducing load on filter. Dirt can be washed off surfaces into wash troughs.

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(Continued from page 94 P&R)

water by adding various proportions of calcium bicarbonate, sodium chloride, and cupric chloride. In the presence of only two of these compounds, the loss in weight of the specimens was small, but in the presence of all three compounds nodular pitting occurred. Corrosion increased with increases in the copper content of the water, and with a given concn. of copper ions reached a max. when the concn. of calcium ions was about 50 ppm, irrespective of the concn. of chloride ions in the range 10–50 ppm. Swansea tap water with added copper salt behaved in a similar manner to a synthetic water with the same concns. of chloride, copper, and calcium bicarbonate. Anodized aluminum was less prone to pitting than normal samples especially if it had been sealed in boiling water after anodizing. The corrosion of normal samples, which are protected by an air-formed film of oxide, can also be reduced by sealing. A mechanism is proposed to explain the initiation and development of pitting.—*WPA*

Cathodic Protection in the Water Supply Industry. P. V. Palmer. *Wtr. & Wtr. Eng.*, 63:409 ('59). In a paper presented at the 1959 annual general meeting of the Society for Water Treatment and Examination, the author outlined the principles of cathodic protection and gave a brief survey of cathodic protection practice in the water supply industry, discussing the use of galvanic anodes and impressed and canalized stray currents. —*WPA*

The Development of Nonconsumable Anodes in Titanium-Platinum for Cathodic Protection. *Wtr. & Wtr. Eng.*, 63:314 ('59). Various applications of the platinized titanium electrode, including its use in electrolytic cells, cathodic protection of marine structures, treatment of water by electrodialysis and in the production of sodium hypochlorite for sterilization purposes, are described and the advantages of this material over the conventional materials are discussed for each application.—*WPA*

Design of Test Systems for Studying the Corrosion of Copper and Copper Alloys by Various Types of Water. M. Obrecht & L. Quill. *Proc. 19th Ann. Wat. Conf., Engrs. Soc. West. Pa.*, p. 33 ('58). After an illustrated description of the failures which occurred in copper and copper alloy water distribution systems at Michigan State University, where the water for the hot water system is treated with sodium zeolite, the authors describe long-term pilot plant expts. to investigate the reasons for the acclerated corrosion of copper and copper alloy tubing, and to determine the operating conditions and design factors necessary to prevent this corrosion. Results are given in tables and graphs. Although complete results are not yet available, the studies have shown that with water softened by sodium zeolite, and containing oxygen and carbon dioxide, red brass is corroded more rapidly, but also more uniformly, than copper; high temps. and high water velocities have adverse effects. Erosion-corrosion is more noticeable on copper than on red brass, especially at high water velocities; using a tube with too small a diam. can result in velocities sufficiently high to cause severe erosion-corrosion. Corrosion depends on a combination of the effects of temp., velocity, and water quality and not on one of these factors alone. The number and severity of failures in the Michigan State University distribution system have been reduced by controlling the rate of flow, reducing the concns. of oxygen and carbon dioxide, improving and controlling regeneration in water softening, and maintaining a positive Langelier index by blending softened and unsoftened water and adding chemicals. The studies are being continued with other alloys and different types of water. In discussion, other examples of the failure of copper and copper alloy water pipes were given, including pipes in the coolers of railway diesel engines; further deductions were made from the exptl. results regarding the factors affecting corrosion; and further tests now being carried out were mentioned including studies on the effect of degasification or deaeration of the water.—*WPA*

Effect of Fluoride on Corrosion. J. A. McCarthy. *Sanitalk*, 7:3:2 ('59). Expts. are reported to compare the corrosion of iron, copper, and lead when suspended in water, drawn from the public supply of North Andover, Mass., with or without the addition of fluoride, equivalent to about 1 ppm fluorine. The results, which are tabulated, show definitely that the amount and rate of solution of all three metals were

(Continued on page 98 P&R)

Fabricator Frank Says . . .

MORGAN NOW HAS SPINNING FACILITIES FOR UNDERGROUND WATER PIPE

Morgan Steel Products, Inc., famous for 25 years for solving large scale fabrication problems, has become equally well-known for specialized work in pipe construction. To meet the need of protective coating for this work, Morgan installed the complex operation described below.

The inner surface of all water pipes must have a tasteless, odorless and perpetual lining to conform to sanitation codes. A specially prepared tar-base formula is evenly deposited inside as a railed carriage proceeds into the massive pipe, which is rapidly rotated.

Note how centrifugal force has deposited an even coating, making a mirror-like finish. This gives the distinct advantage of maintaining the highest possible flow coefficient. The nature of the coal tar lining itself prevents tuberculation.

Overlapping layers of heavy asbestos felt wrapping are firmly bonded to or imbedded in an enamel coating. This provides a shielding and reinforcing agent for the outside coating which has been previously applied.

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The final process is application of whitewash which is applied only to the exterior surface to protect the enamel against hot sun exposure.

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(*Continued from page 96 P&R*)

unaffected by the presence of the added fluoride.

Anticorrosion and Anti-incrustation Treatments of Water—Economic Factors. T. SAMUEL. *Bul. Centre Belge Etude et Document. Eaux* (Liege), 44:95 ('59). The author discusses the effect of anticorrosion and antiincrustation treatments on the cost of boiler feedwater (for high- and low-pressure boilers), cooling water, and wash water. Special attention is given to water for high-pressure boilers, for which the only satisfactory method of treatment is distillation or demineralization followed by deaeration. The costs of treating water from the usual sources, such as rivers and lakes, are compared with those for treating sea water by various processes.—*WPA*

Water Treatment for Polymetallic Cooling Systems. E. H. HURST. *Proc. 19th Ann. Wat. Conf., Engrs. Soc. West. Pa.*, p. 17 ('58). The use of more than one metal or alloy in a cooling system is discussed with reference to the severe corrosion which may be caused by galvanic action. Galvanic corrosion may result from the direct coupling of one metal with another, or from the corrosion of one metal, producing metallic ions which can then migrate through the system and set up individual galvanic cells. The control of galvanic cells by metallic or organic coatings or by cathodic protection is not usually applicable to cooling water systems, but corrosion inhibitors can be added to the water. The inhibitor or combination of inhibitors must be chosen according to the particular metals to be protected. A lab. procedure using corrosion test panels, coupled or uncoupled, is described for use in evaluating the ability of various inhibitors to control corrosion in polymetallic systems under simulated operating conditions. Results of various tests are given in tables and photographs. In closed systems, a boron-nitrite inhibitor is particularly effective where copper, steel, and aluminium surfaces are present, and is not affected by the presence of glycol antifreeze. Buffered-chromate inhibitors are satisfactory for closed systems incorporating cast iron, steel, copper, or copper alloy, but not when aluminium is present; a combination of chromate and nitrate offers protection to all metals including the serious galvanic couple of copper and aluminium. In open recirculating systems or cooling towers these inhibitors do not give adequate protection at economic doses, but chromate-based or polyphosphate-based inhibitors can generally be used to protect ferrous metals and copper or copper alloys; aluminium-copper couples cannot be protected economically, but a method using a combination of polyphosphate, citrate, and mercaptobenzothiazole has been used successfully to protect aluminium in the presence of copper ions in the water. In discussion, experiences are reported on the use of corrosion inhibitors at various industrial plants and research labs.—*WPA*

BACTERIOLOGY

The Effects of Storage Upon the Counts of Coliform Organisms and *Esch. coli* in a Water From North Wales. H. COLES & N. SIMPSON. *Proc. Soc. Wtr. Treatment Exam.*, 7:173 ('58). Expts. were made over a period of 3 yr on the effect of storage for 1, 2, and 3 days on the tot. coliform and *Esch. coli* counts of water from a single source. The water supply at a creamery in North Wales was found to be suitable. The water is obtained from a mountain lake, and is chlorinated before passing through a 5-mi pipe to the sampling point; no residual chlorine was detected in any sample. It was found that after storage for 1 day, there frequently were changes in both tot. coliform and *Esch. coli* counts, reductions in bacterial nos. being much more frequent than increases. The proportion of samples showing low counts increased with increase in storage period. With all periods of storage the greatest loss of coliform organisms occurred in samples of poor bacteriological quality, and there tended to be a greater loss of coliform organisms than of *Esch. coli*. The results confirm that samples of water for bacteriological examination should be examined as soon as possible after collection in order to obtain reliable results.—*WPA*

***Coli-aerogenes* Bacteria in Farm Water Supplies.** S. THOMAS; P. HOBSON; & R. DRUCE. *J. Appl. Bact.*, 22:32 ('59). In continuation of preliminary studies on *Coli-aerogenes* bacteria in farm water supplies a study was made of the incidence of different types of *coli-aerogenes* bacteria isolated at 30° and at 37°C from 645 farm water sup-

(*Continued on page 100 P&R*)

Installation: **Armco Water Pipe**
Shutdown Time: **Minimum**

A highway project required relocation of an existing water line in Ambridge, Pennsylvania. Because it can be installed easily and quickly, Armco Welded Steel Pipe was specified for the job. The line was laid in place from the center out, and the two end connections were installed last. By this method, water was shut off only a short time. (Incidentally, difficult trenching in the sandy soil necessitated the trench being twice as wide as usual.)

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(*Continued from page 98 P&R*)

plies. *Klebsiella* constituted 50 per cent of the cultures isolated at 30°C, while *Esch. coli* was the dominant type in cultures isolated at 37°C. *Coli-aerogenes* organisms, mainly 37° negative strains of *Citrobacter freundii* I and *K. cloacae,* were found in waters of good sanitary quality derived from protected springs and wells. In polluted water the dominant organism was *Esch. coli,* which formed at 43% of the isolates at 30°C and 76% of those at 37°C. Examination of a series of fortnightly samples from 11 supplies showed a marked seasonal variation in the incidence of different types isolated at 30°C; *Esch. coli* formed a higher proportion in summer than in winter, while 37° negative strains of *Klebsiella* and *Citrobacter* formed a higher proportion in winter than in summer.—*WPA*

Observations on the Isolation of *Salmonellae* From Selenite Broth. H. G. SMITH. *J. Appl. Bact.,* 22:116 ('59). Studies on the effect of different carbohydrates in selenite broth on the growth of enterobacteria showed that while mannitol and lactose reduced the growth of *Coli-aerogenes* bacteria considerably, mannitol improved the growth of *Salmonella typhimurium.* With mixed cultures of *Citrobacter freundii* I and *Salm. typhimurium* the presence of lactose, utilizable by the former, adversely affected the viable count of the latter organism. Expts. with routine feces specimens showed that selenite broth was an efficient selective agent with MacConkey's agar but much better results were obtained when it was combined with deoxycholate-citrate agar. The addition of gentian violet to selenite broth improved its selectivity for most *Salmonella* types when MacConkey's agar was used for final isolation.—*WPA*

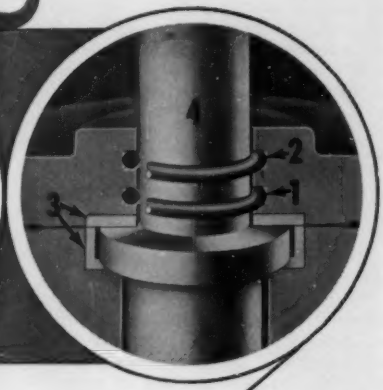
***Pseudomonas fluorescens*, a Soil and Water Bacterium—III. Identification of *P. fluorescens* Strains by Bacteriophages.** K. KLINGE. *Arch. Mikrobiol.* (Ger.), 34:270 ('59). In view of the effect of *Pseudomonas fluorescens,* which produces an active agent lethal to ameba and other protozoa, on self-purification of seepage water, the author describes expts. on the identification of *P. fluorescens* strains by bacteriophages. After enrichment of the *P. fluorescens* and *P. putida* strains in sewage, 32 bacteriophages were isolated. Several phages with morphologically different phage holes could be cultured on one bacterial strain; these had not always a different lysis spectrum. None of the phages dissolved *P. aeruginosa* strains; only 2 *P. fluorescens* phages dissolved *P. putida* strains; no *P. putida* phage dissolved *P. fluorescens* strains. The results of phage titration and the lysis spectra are described. Subcultures of some *P. fluorescens* strains are compared as regards biochem. action, reciprocal restriction of growth, and phage sensitivity.—*WPA*

Inactivation of the Oxidation Capacity of *Nitrobacter winogradskyi* Buch. G. SEELER & H. ENGEL. *Arch. Mikrobiol.* (Ger.), 33: 387 ('59). On exhaustion of the substrate, cells of *Nitrobacter winogradskyi* undergo increasing inactivation of their capacity to oxidize nitrite. The authors investigated possible methods of quantitative measurement of inactivation and found that the only possibility was direct microscopic counting of the cells. The membrane filter method used is described. An account is then given of expts. showing that resting cultures of *Nitrobacter winogradskyi* rapidly lose their power of oxidizing nitrite and that for complete restoration of this action the presence of carbon dioxide is also necessary.—*WPA*

The Effect of Bacteria on Radiophosphorus Uptake of *Fucus vesiculosus.* W. D. WATT. *Biol. Bul., Woods Hole,* 117:421 ('59). A study was made of the exchange of radioactive phosphorus between *Fucus vesiculosus* and sea water. Under the conditions of the expts., which were carried out in darkness at 23°C, the turnover time was independent of biomass and volume of water. The amount of phosphorus (added as phosphate) in the water declined exponentially to an equilibrium value which remained constant for at least 60 hr, indicating that no measurable net uptake of phosphorus occurred during this period. The mean turnover time in freshly collected sea water was found to be 18.8 hr. When the antibiotic tetracycline hydrochloride was added to the water, the mean turnover time became 37.6 hr, and similar results were obtained with sea water which had been autoclaved or passed through a membrane filter. The increase in turnover time with the reduction in bacterial populations was accompanied by an increase in the radioactive phosphorus

(*Continued on page 102 P&R*)

DOUBLE SEALING



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FIRE HYDRANTS VALVES SINCE

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(*Continued from page 100 P&R*)

accumulated in the algal tissues, suggesting that the aquatic bacteria take up the dissolved inorganic phosphorus and release it again in some form, probably organic, which is not immediately available to the plant.—*WPA*

Uptake of Strontium by *Syracosphaera carterae*. R. A. LEWIN. *Biol. Bul., Woods Hole,* 117:384 ('59). Coccolithophores frequently constitute the main component of marine phytoplankton, especially in warmer seas, and as their cells are covered with sculptured scales of calcium carbonate they are evidently one of the chief biological mechanisms for calcium deposition in nature. The degree of strontium incorporation by coccolithophores is therefore of practical importance in relation to the rate of entry of strontium-90 into the biosphere. Expts. were carried out with cultures of *Syracosphaera carterae* in synthetic sea water to which various concns. of strontium were added. After growth for 25 days, the cells were harvested by differential centrifugation, washed, dried, and examined by x-ray diffraction and flame photometry. In the absence of strontium the cells consisted of pure calcite. In the presence of strontium, the concn. factor was approximately 0.02, indicating a high degree of discrimination against this element under the conditions of the expt. It is not known whether this selectivity is due entirely to chemical forces during crystallization of the calcite, or partly to biological specificity.—*WPA*

Removal of Coxsackie and Bacterial Viruses in Water by Flocculation. II. Removal of Coxsackie and Bacterial Viruses and the Native Bacteria in Raw Ohio River Water by Flocculation with Aluminium Sulfate and Ferric Chloride. S. L. CHANG ET AL. *Am. J. Public Health,* 48:2:159 ('58). In an earlier investigation a study was made of the relative efficiency of aluminium sulfate and ferric chloride for the removal of Coxsackie and bacterial viruses from water. In this investigation the effectiveness of flocculation procedure as practiced in water treatment was investigated for removing viruses and native bacteria from raw Ohio R. water. Detns. were also made of the critical contact time between microorganisms and coagulant in water and of the interference effect of gum-arabic on the removal of viruses and bacteria from water by means of flocculation. Coagulation consisted of a 2-stage process, 1st with aluminium sulfate, and in the 2nd stage the supernatant from the first was treated with ferric chloride and lime to produce a final pH in the range 7.3–8.4. Considerable removal of both virus and bacteria was achieved by the 2-stage coagulation process —over 99%; removal of the Coxsackie virus was slightly higher in general than that of the bact. virus. The critical time for the formation of the coagulant-microorganism complex with practical doses of aluminium sulfate was a matter of only a few min. Gum-arabic, at a concn. of 20 ppm, completely prevented floc formation with consequent failure to remove viruses and bacteria from Ohio R. water. As a result of the observations, suggestions are made for improving the efficiency of flocculation to remove viruses as well as bacteria.—*BH*

Studies on the Role of Glycosides in the Identification and Differentiation of Enteric Bacteria. L. R. WORTHEN ET AL. *Appl. Microbiol.,* 6:384 ('58). Expts. have shown that glycosides other than salicin may be used to differentiate between members of the Enterobacteriaceae. Methyl-α-D-glucoside could be used to differentiate *Esch. coli* from *Aer. aerogenes,* and was also consistently fermented by *Salmonella* ser. *florida.* The behavior of *Esch. coli* and *Aer. aerogenes* on arbutin agar was also sufficiently different to suggest that this medium might be used as an adjuvant test for comparing these two cultures. All cultures of *Shigella sonnei* were capable of producing acid from arbutin. Both phenol red and bromcresol purple were satisfactory as pH indicators. The glycosides were found to be heat stable as used in these tests.—*WPA*

The Survival and Multiplication of Typhoid, Paratyphoid and Dysenteric Bacteria in Water. N. R. DYADICHEV. *Hyg. & Sanit.* (Moscow), 24:4:11 ('59). An exptl. study is reported on the survival and multiplication of typhoid, paratyphoid, and dysenteric bacteria in ordinary tap water and in similar water to which had been added various amts. of organic substances in the form of feces or nutrient broth. The results, which are tabulated and shown graphically, indicate that the most important factor inhibiting the growth of intestinal pathogenic bacteria in water is the lack of a sufficient concn. of organic substances suitable for bacterial nutrition.—*WPA*

Newark's twin steel conduits still going strong after more than 60 years of service

The photograph above was taken in 1933, when construction of a highway required the relocation of a portion of Newark, New Jersey's twin Pequannock aqueducts. Those 26-mile-long steel lines were old-timers even then—and they're still going strong today!

Pequannock Number 1, 48 in. ID, went into service in 1892; its "twin" was completed in 1896. (In fact, nearly 250,000 ft of large-diameter steel pipe were put into service before the turn of the century.)

These venerable steel lines were cleaned and re-lined once since they were first installed, and their carrying capacity is "as good as new." The City expects them to remain on the job for another thirty or forty years.

From coast to coast, cities have reported forty, fifty, or more years of excellent service from large-diameter steel mains. And with our vastly improved coating and lining materials, you can confidently expect even better performance from the steel pipe you install today.

If you're planning a new main, you'd be wise to consider Bethlehem Tar-Enameled Steel Pipe. You can get full information from the Bethlehem sales office nearest you.

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(Continued from page 48 P&R)

systematic study of management principles and techniques.

The first of its type, devoted to the recognition of a water utility as a business enterprise which should be self-sustaining, the course this year will cover the basic fundamentals of management, as well as elements of rate making, business speaking, labor relations, and leadership training.

Information is available from Hugh Davison, short-course supervisor, 116b Illini Hall, Champaign, Ill. The fee is $45, plus lodging and meals at $37.50.

Robert W. Angus, professor emeritus of mechanical engineering, University of Toronto, died Jun. 30, 1960, at Danville, Pa., where he was visiting a son. He was 86 years old. Following graduation from the University of Toronto in 1894, he spent several years in the US, before returning to the university in 1900 as a lecturer. He became professor of mechanical engineering in 1906.

A member of AWWA since 1917, he was nominated for the Fuller Award in 1942 and received Honorary Membership in 1945. He was also an honorary member of the Engineering Institute of Canada, the Institute of Mechanical Engineers (Great Britain), and ASME.

Robert T. Baldwin, former secretary of The Chlorine Institute, New York City, died Jul. 12, 1960, at Charlottesville, Va., at the age of 78. He had served the organization as secretary from 1924 to 1959 and as treasurer from 1928 to 1959. As a tribute to his service to the chlorine industry, he was appointed as the institute's first and only honorary member in June 1959. He was a member of AWWA since 1924.

S. Willard Jacobs, also prominent in The Chlorine Institute, died on Jul. 2, 1960, in New York City, at the age of 73. He had been vice-president and later chairman of the board of the Niagara Alkali Co. until its merger in 1955 with Hooker Chemical Corp. He served the institute for many years, as vice-president (1929–32) and then as president (1933–48). A member of AWWA since 1919, he was a Life Member.

Harold Shand, assistant general manager and assistant chief engineer, Greater Winnipeg (Man.) Water District, died on May 14, 1960, in Winnipeg. He had worked for the district since 1916 and assumed his current position in 1950. He was an AWWA member since 1945.

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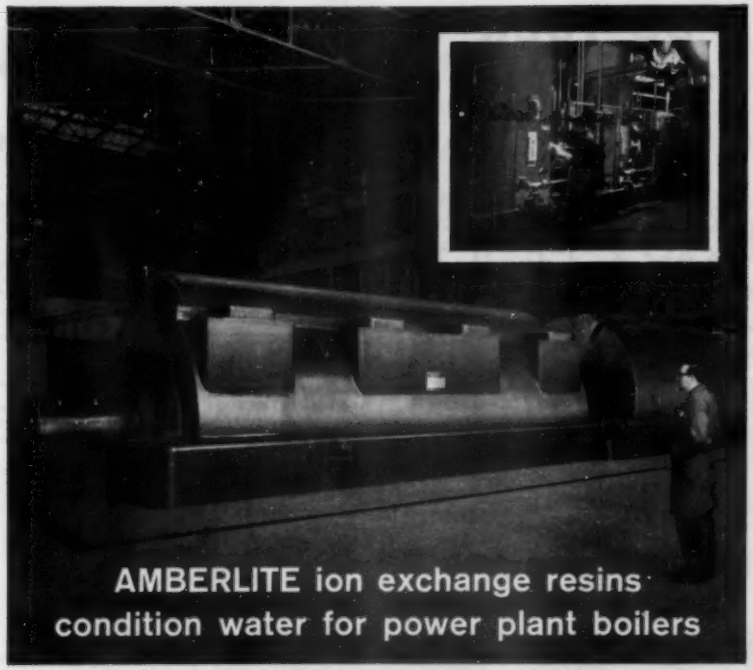

INSET: *Water conditioning units at Duke Power Company, Riverbend Steam Station near Charlotte, N. C.* AMBERLITE *ion exchange resins deionize water for boiler make-up.*

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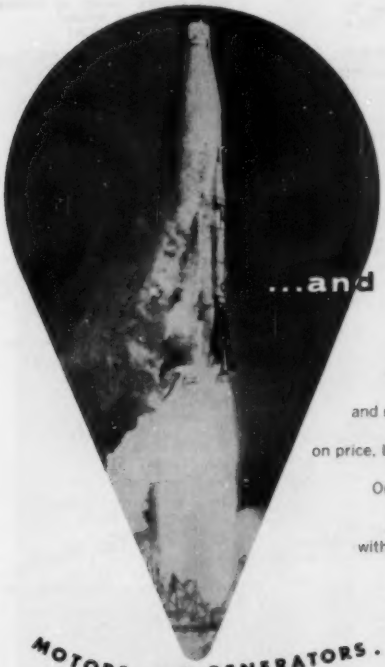

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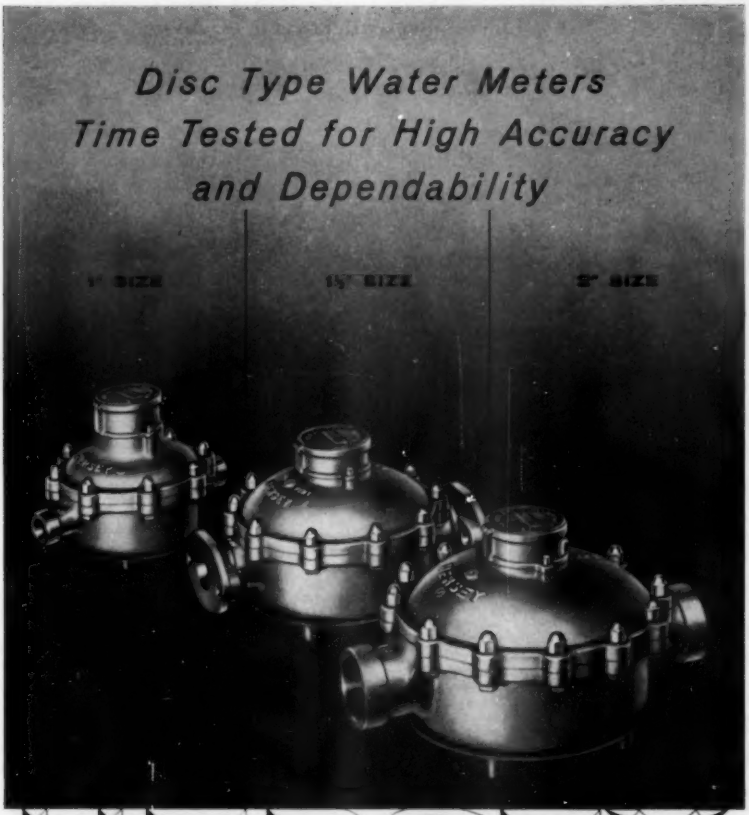

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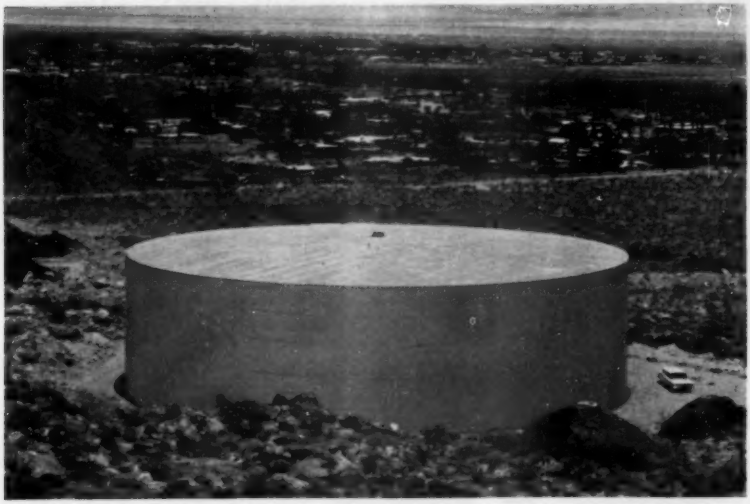

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Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Proportioneers
General Filter Co.
Industrial Chemical Sales Div.
Permutit Co.
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
DeZurik Corp.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
Rockwell Mfg. Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey-Sparling Meter Co.

Valves, Electrically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pelton Div., Baldwin-Lima-Hamilton
Henry Pratt Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
Rockwell Mfg. Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M & H Valve & Fittings Co.
Mueller Co.
Rockwell Mfg. Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
B-I-F Industries, Inc.—Builders
Rockwell Mfg. Co.
Simplex Valve & Meter Co.

Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Well Reconditioning and Formation Testing:
Halliburton Co.
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

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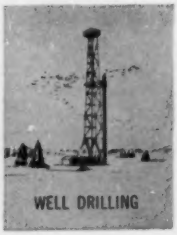

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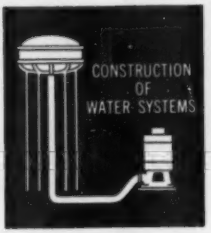

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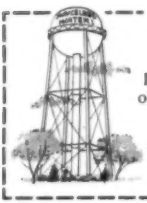

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